HOW WE LEARN ABOUT CLIMATE CHANGE:
Environmental Education in North Carolina

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ABSTRACT

Carly Apple: How We Learn About Climate Change: Environmental Education in North Carolina
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The research reported in this thesis examines the structure of environmental education on global climate change in North Carolina. Although the quality of public knowledge is slowly improving due to media influences, the status quo of science literacy is insufficient to understand the complexities of climate change. Understanding is a fundamental step towards engaging in more sustainable lifestyles and supporting efforts to mitigate dangerous climate change. Educators must take into account the unique challenges associated with this topic such as risk perception, prior knowledge, basic science literacy, and the role of fear when designing education tools. Museums and science centers have an opportunity to use their resources to effectively and creatively educate the public about the complexities of global climate change. Education at a young age is the best way to instill an appreciation for the environment, the nature of science, and an individual's responsibility for a global problem.

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EE	Environmental Education
ERB	Environmentally Responsible Behavior
GCC	Global Climate Change
MPSC	Morehead Planetarium and Science Center

Chapter One

Environmental Education in North Carolina

Introduction

Combating global climate change[1] (GCC) is one of the most challenging and important problems that this generation faces. Measures to stop or slow GCC in the United States are beginning to form but quick and effective action is vital. Action requires the support of the public, but so far the public has been generally apathetic in its response. Without the support of the American people – who must soon change their lifestyles if efforts to reduce greenhouse gases are to succeed – climate change will increase in momentum and severity all over the world. Research on environmental education has shown that positive environmental voting, consumption, and behavior patterns are largely determined by how much a person knows about a topic (Roper iPOLL, 2002; Patchen, 2006). Reasons for lack of public support are complex, but can be partly attributed to inadequate public education on the issue.

If environmental legislation that can effectively help stop or slow GCC is passed, it will be the product of extensive civic lobbying. This kind of public support can only be

[1] The terms "global warming" and "global climate change" (GCC) are generally interchangeable for the purpose of this paper. "Global climate change" is more inclusive as it takes into account the various climate shifts that are taking place. "Global warming" can be too simplistic because it ignores all other changes. However, because most people, especially children, do not completely understand the term "climate," many communication experts prefer the term "global warming" to refer to the various changes that are associated with global climate change.

achieved and sustained if voters and policymakers understand the basic scientific, social, political, and technological causes of a problem. Understanding such a complex topic in order to vote knowledgeably requires a strong science background and environmental literacy. This kind of background cannot be gained from the present public education system.

In this thesis I aim to help guide school curriculum designers, science center educators, and environmental communicators in general who wish to develop education resources about global climate change. By examining the structure and condition of environmental education in North Carolina public schools, I hope to expose certain deficiencies and suggest ways that these conditions can be improved. North Carolina can serve as an example of what challenges other states face. Due to its unique characteristics and global implications, GCC is a topic unlike any that public educators have addressed up to this point. I hope that this thesis can serve as a direct education contribution with immediate relevance.

The Role of Environmental Education

Recent scientific evidence showing that humans are strong contributors to a changing climate has been more unanimous than ever. A recent report by the Intergovernmental Panel on Climate Change (IPCC) stated this consensus clearly. Using evidence including ice cores that record weather patterns from the last several thousand years, it has been determined that concentrations of certain greenhouse gases (namely carbon dioxide, methane, and nitrous oxide) "have increased markedly as a result of human activities since 1750 and now far exceed pre-industrial values" (IPCC, 2007, p. 2). The report goes on to state specifically that the rates of anthropogenic greenhouse gas

emissions are increasing:

> The annual carbon dioxide concentration growth rate was larger during the last 10 years (1995-2005 average: 1.9 ppm per year), than it has been since the beginning of continuous direct atmospheric measurements (1960-2005 average: 1.4 ppm per year) although there is year-to-year variability in growth rates. (ibid)

The IPCC report is a synthesis of thousands of other studies on weather and climate. Its report shows that greenhouse gas levels will continue to increase if the status quo continues. Extensive analysis of mitigation scenarios also set forth by the IPCC concluded, "Decisions to delay emission reductions seriously constrain opportunities to achieve low stabilization targets (e.g. stabilizing concentrations from 445-535 ppmv CO2-equivalent), and raise the risk of progressively more severe climate change impacts and key vulnerabilities occurring" (Fisher, 2007, p. 173). Scientists have come to a clear consensus that the time to lower greenhouse gas emissions has come. Computer models show unambiguously that a "critical threshold is approaching. Crossing over it will be easy, crossing back likely impossible" (Kolbert, 2006, p. 3).

Broad economic incentives such as taxes on carbon and subsidies for clean energy sources are likely to be a vital part of any future climate change mitigation in the United States. In order for these to be established, however, voters and citizens in general need to be educated about why these steps are beneficial despite their initial expense. Environmental education is an important tool that teaches people how they can personally help solve/prevent problems. Although technological solutions may be created, costly changes require support of a generally reluctant public.

Education can illuminate incentives, showing people both how they could personally benefit from changing their behavior, and how they would suffer from a lack of change. Meaningful lifestyle changes will require a certain amount of direct financial

and lifestyle sacrifice from individuals. Therefore, personal understanding about how climate change will affect individuals and communities is essential for positive environmental policy implementation.

Education can also fuel a change in attitudes that are fundamental for new policy success: "Some of the changes necessary may in theory be achieved entirely by governments through regulation. But others will require individuals to *choose* to behave differently and allow or encourage politicians to introduce policies to reduce our carbon emissions rather than punish them for trying at the polls" (Retallack, 2006, p. 1).

Changes in attitudes come from early education that builds awareness and empowerment. As will be discussed in chapter four, people are more likely to self-identify as environmentalists if they are exposed to these ideas at an early age (Falk & Dierking, 2002; O'Connor, 1999). Encouraging this kind of education and specifying it in governmental policies can lead to future orchestrated, collective public action to mitigate the effects of global climate change as well as other merging but as yet little-known environmental threats.

United States Environmental Education Policies

With enough information and education, widespread action of individual people or organizations can lead to implementation of policies that are necessary to mitigate global climate change. As the Rio Declaration states, "Environmental issues are best handled with the participation of all concerned citizens…At the national level each individual shall have appropriate access to information concerning the environment…

and the opportunity to participate in the decision making processes" (quoted in Speth, 2004, p. 181). This kind of responsible participation begins with knowledge.

An MIT study shows that there is currently a lack of support to fund measures that would stall global climate change, including cutting down on greenhouse gas emissions and investigating carbon sequestration technology. Implications of this disinterest include policy stagnation. The results suggest that,

> … change in US climate policy will not be led by public opinion. Elected officials will have to provide leadership - a task they will find difficult because achieving significant reduction of the greenhouse gases linked to climate change may involve economic costs well above what the average consumer is willing to pay. (Stauffer, 2005)

Governmental policy is a common tool to discourage environmentally destructive behavior and consumption patterns among citizens and industry. Effective policy and government-funded education can help solve environmental problems related to overconsumption, pollution, the misuse of natural resources, and prevent problems like these from worsening. Effective environmental education funding should focus not only on the education of individuals, but also emphasize teaching methods that have been shown to lead to improved consumption and conservation behavior.

The current United States Administration has consistently expressed skepticism about the importance of policies that would limit greenhouse gas emissions. Although President Bush recognizes that GCC is an issue that must be addressed, his espoused political position is based on faith in technology. "Sustained economic growth is the solution, not the problem" (Executive Summary, 2007). Recently the Administration has begun to shift its policy into a more proactive approach towards global climate change mitigation. It invites developing countries to join the US in efforts like reducing the

greenhouse gas intensity of the U.S. economy by 18 percent in the next 10 years, protecting and providing transferable credits for emissions reduction, and to increase funding to climate change mitigation spending by $700 million (ibid). Throughout the Executive Summary report's discussion on climate change, a strong emphasis is made on reaching these goals without sacrificing any economic growth (Executive Summary, 2007). The concept of "greenhouse gas intensity," for example, accommodates higher total greenhouse gas emissions while increasing efficiency standards of existing and new technology. These changes are improvements from previous policy statements, but still need to be supported by government officials and translated into tangible policy action. If the public isn't made aware of the urgency of the problem, their representatives have no mandate or even motivation to act. Elected officials in the United States who take a proactive stand on the issue often risk being voted out of office.

Effective national environmental education faces substantial roadblocks. Whether changes are made now to incorporate long-term goals, or hardships due to environmental degradation force changes in the future, the public will feel the effects of global climate change. The problem must eventually be taken seriously and real economic sacrifices are inevitable regardless of how the US decides to respond. Forward-thinking policy shifts will only happen if an educated public is willing to make the sacrifices necessary and vote for measures restrict our country's carbon footprint.

EE Policies and Programs Already in Place

In 1970, as part of the kickoff of what would be called the "decade of the environment," Richard Nixon signed the first Environmental Education Act into law.

This Act primarily established the Office of Environmental Education (OEE). This office was designed to help generally "increase public understanding of the environment" (Baker, 2006). Its mission was to award grants to develop environmental education curricula and provide professional development for teachers. It was also intended to support internships and fellowships that would encourage environmental professions, fund national environmental awards, and fund workshops and conferences to promote EE (ibid).

The Environmental Education Act was originally funded through 1975 with the intention of refunding it at that time. However, by then it had lost momentum and was not funded for four years. In 1979 it was placed under the newly formed Department of Education. It was repealed altogether in 1981 as part of a "budget reconciliation bill" that claimed that environmental education was a job of the states, not of the federal government (Baker, 2006). By 1985, North Carolina, along with other states facing tight budgets, decided to take earth science out of eighth grade classrooms, where it had been required since the 1970s. Education administrators at the time said that they were not planning on putting it back into other grade levels (Watson and Tucci, 2002).

Due to public outcry at the absence of environmental science in classrooms, the 101st Congress passed the National Environmental Education Act (NEEA) of 1990. This new act was supposed to bring back standards of classroom environmental education. It reestablished the OEE, but this time put it under the EPA. Ultimately, this measure was also weak; the act didn't officially go into force until 1993, only to have its authorization expire three years later. According to the American Geological Institute's Government Affairs Program, the program continues to receive funding through annual appropriations

bills, but doesn't have a stable yearly budget. Generally, the OEE tries to give one dollar per every two dollars given by private donors (Baker, 2006).

According to the 1990 NEEA, $2-$3 million in funds is provided by Congress through the Environmental Education Grant Program under the EPA. The Office of the Administrator directs the Office of Children's Health and Protection and Environmental Education (OCHPEE), which in turn presides over the Environmental Education Division of the EPA. The Environmental Education Grant Program is housed in this division. According to this Program, priorities are to fund projects that:

> ...build state capacity to deliver EE programs, use EE to advance state education reform goals, improve teaching skills, educate the public through community based organizations, educate teachers, health professionals, community leaders, and the public about human health threats from pollution, especially as it affects children, and to promote environmental careers. (EPA 2006)

So far, awards from the National Environmental Education Act of 1990 have only been given to educators who are committed to teaching traditional, classroom-only environmental education. Instead of increasing the amount of money allotted to this issue since 1990, money and services have been taken away. Furthermore, a recent amendment to the NEEA revises and renames certain national environmental education awards, eliminating the ones named for Theodore Roosevelt, Henry David Thoreau, Rachel Carson, and Gifford Pinchot. In their place is an award called the John H. Chafee Fellowship program that provides five individual one-year $25,000 graduate fellowships in environmental sciences, two of which are only offered at the University of Rhode Island (H.R. 4745, 2000). Of the 3,000 grants awarded since 1992, none are specifically earmarked to educate students or educators about the growing and complex problem of global climate change.

In 1996, a major proposal was passed that changed the force of the National

Environmental Act of 1990. Several politicians expressed concern that the funding for the NEEA was used to support partisan lobbying. Chairman Goodling (R-PA) of the House Committee on Education and the Workforce Subcommittee on Early Childhood, Youth, and Families claimed that "There are concerns that certain environmental curricula favor a specific perspective or agenda and any authorization legislation should ensure that the program has a *sound science* foundation" (emphasis added) (Baker, 2006). The term "sound science" is problematic for a few reasons, especially when used as a basis for decision in a political arena. Co-opting this term gives the impression that special interests and emotions are left out of an evaluation. It invokes a sense that the rationale is based firmly in the "scientific" reality of a situation, rather than any political motivation (Bocking, 2006). Ultimately this proposal continued to weaken the NEEA by threatening to slow the adoption of new science, especially controversial science on topics like global climate change, in school curriculums.

Effects of EE Policies in North Carolina

The National Environmental Education Act of 1990 had no implementation plan in North Carolina until 1996, when the state created its "Environmental Education Certification" program under the OEE. The program certifies teachers to be nationally accredited in environmental education. In North Carolina, teachers must pay $25 to complete 200 hours of professional development in the environmental science field. Six hundred teachers have been accredited so far, but the program itself has yet to be endorsed by the North American Association for Environmental Education (NCEE, 2006). Because of the extensive time commitment that this certification requires, most of

the people who have been certified are informal environmental educators. There is little initiative for public school teachers to spend the time and money on the certification process.

Accreditation is desirable because many teachers have no training to teach the new "earth and environmental science" class that was added by the North Carolina school system in 1997[2]. This addition to the curriculum required a battle and the successful conclusion was largely due to the pressure of an interest group called the "Education and Industry Committee for Earth Science in NC," which had been lobbying for 15 years since the cancellation of earth science in the school system. The group is a coalition of scientists from business and industry, public and private universities, the EPA, and vaguely labeled "consultants" (Watson & Tucci, 2002). According to this group, earth science is important for two reasons: "students need to know earth science not only to be good citizens, but also to protect themselves from the effects of natural disasters" (Watson & Tucci, 2002). One committee member described his cause like a crusade, "We're missionaries out there, trying to spread the word and involve others in our cause" (ibid). This group convinced the State Board of Education to make earth and environmental science one of the three science courses that high school students are required to take before graduation (Watson & Tucci, 2002).

The name earth and environmental science was the result of a compromise. The committee had not wanted the word "environmental" in the heading of the course name. There is a very subtle difference here that the group never officially addressed. They didn't want the term in the title but conceded with the comment that, "The reality of it is

[2] NC is unique in calling it by the combined name (Hasse, personal communication, June 17, 2006).

that when we talk about the environment, we talk about the atmospheric sciences, the weather, the Earth, different kinds of soil and rocks, weathering and erosion" (Watson & Tucci, 2002). What is missing from this list is any mention of how humans as a species have affected the earth and its systems. This human/natural systems link is arguably what most people would connote with the term "environmental." Stephen Bocking (2006) acknowledges that the term itself refers to "a large and diverse body of activities," but within this term one could include anything from "toxicology to fisheries biology to atmospheric chemistry" (p. 15). It could certainly include anthropogenic environmental changes. The committee, however, claims that the definition of "environmental science" is not different than "earth science," and therefore accepted it despite the "redundancy" (Watson & Tucci, 2002).

The earth and environmental science course is novel in its explicit attempt to try to separate some of the more frequently blurred lines between science and religious beliefs. It is especially aimed at improving the science literacy of students. According to Eleanor Hasse, the Secondary Science Consultant for NC public schools, it "is one of the only courses where students go out and analyze and collect their own individual data" (Hasse, personal communication, 6/17/2006). It adheres to the National Science Education Standards that were set in 1996 that are intended to make sure that potentially contentious issues like evolution and climate change are taught according to the best peer-reviewed scientific data available. They state, "explanations of how the natural world changes based on myths, personal beliefs, religious values, mystical inspiration, superstition, or authority may be personally useful and socially relevant, but they are not scientific" (Public Schools of NC, 2004). The course description also states that one of its

main focuses is “helping students look at science as a future vocation” (ibid). This is of course an important motivation to learn, but can be limiting if it is the only reason a science background is deemed valuable. A further goal of science education should be to give students tools to become informed citizens and voters.

In the 1999 version of the earth and environmental science curriculum, discussion of environmental issues was left until the end of the year. In the Chapel Hill school system, this topic was recently moved so that it could be addressed earlier, with the hope that these issues could be incorporated throughout all of the units. Hasse asserts that, “In each [unit’s] goal, there should be an objective that incorporates [environmental education] throughout. This is reflected in the new curriculum” (Hasse, personal communication, 6/17/06). Not all schools in North Carolina see it this way however, and many continue to strictly follow the order of the proscribed curriculum.

Although the earth and environmental science class has been added to the Curriculum, there have been major roadblocks to its implementation. Almost no money was directed to teacher training, and money for the certification process (which is not required) would have to come out of the teachers pockets themselves (NCEE, 2006). The Environmental Education Program in North Carolina has said that it is concerned that this new requirement will be difficult to carry out in conjunction with a shortage of teachers and the “stringent requirements imposed by federal legislation with the ‘No Child Left Behind Act’” (ibid). This also might further aggravate the current trend of a heavy focus on standardized tests by necessitating a new end-of-course test (in NC, the earth/environmental science course is the only science without one). Additionally, there is some worry by teachers and parents that the new course would take away from time

spent on AP courses. The school board admits that full implementation of this new class will require major investment and budget changes at the local level (NCEE, 2006).

North Carolina Curriculum Process

The North Carolina state curriculum process involves a five-year cycle of revision. Subjects are staggered so that a different subject is reviewed each year. Education reform efforts are generally initiated through state-level and local frameworks. Reforms like these have the advantage of higher levels of implementation than national initiatives, but because of funding challenges and the absence of a federal mandate, have lower levels of real program reform in both quantity and quality (Bybee, 1995).

In North Carolina, the state Department of Public Instruction is in charge of setting standards and asking for revisions in the curriculum. Currently, the science curriculum is between revisions. The most recent changes to the curriculum were adopted in 1999, revised in 2004, and went into full effect in 2007. Testing changes along with curriculum but there has been a three year lag time, meaning that most teachers are probably teaching the old curriculum (Hasse, personal communication, 6/17/06). The earth and environmental science addition to the curriculum will be subject to testing for the first time in 2007. So far, grades 9-12 have still been working from 1999 documents. In the 2007 school year, this should change to 2004 requirements (Public Schools of NC, 2005). For teachers who are untrained in the new subject matter, there are support

documents available online created by committees of teachers[3], though scientists are also asked to contribute to these supplements. Staff members of the Office of Environmental Education attend meetings and are invited to add input. OEE staff "try to ask appropriate people to be on the committee" (Hasse, personal communication, 6/17/06). Teachers are asked to submit lesson plans/activities for approval to become a state resource. Representation from these different groups is required during the curriculum revision process. Any new science information on global climate change is taken into account here. The committees will be reformed in 2008, and a new curriculum review will happen at that time (Hasse, personal communication, 6/17/06).

Conclusions

New policies must be created to ensure that minimum environmental education levels are met. The current curriculum, established nationally by the OEE, does not explicitly address environmental issues. These kinds of requirements have been shown to work in the past. For example, a study on how new education standards in Michigan were implemented at the ground level showed that policies, even weak standards, raised the bar for the school systems that struggled the most. One administrator explained, "The state probably got us going a little sooner. We definitely needed it because there was nothing. If a new teacher came in there really wasn't anything other than a textbook to guide, you know… that was the curriculum" (Spillane & Callahan, 2000, p. 408). Admittedly, creating federal standards for environmental education could also contribute

[3] Many free teaching resources created by a variety of non-profit organizations, state education providers like the Department of Public Instruction, and education specialists can be found online. A list of some of the best in North Carolina can be found in Appendix Two.

to the barrage of testing that many schools must endure, rather than looking at what is best for a particular school system.

The process of improving the education system so that it effectively teaches students about issues that will impact their lives will be a long and complicated process. However, there are examples of what has worked, as well as suggestions for how other public institutions can step in and help. The following chapter will address ways that North Carolina school curriculum could be improved so that it more thoroughly educates young people about environmental issues such as global climate change.

Chapter Two

Formal Global Climate Change Education

North Carolina Environmental Education Curriculum

North Carolina currently bases its curriculum on the National Science Education Standards (NSES). In the extensive descriptions of what students are expected to know for each science unit, the word "climate" is briefly mentioned. Global temperature and the geological history of changes in global temperatures are discussed in terms of how they are controlled by water and carbon cycles, but the outline does not mention any other possibility of climate forcers (NSES, 2007). Unless teachers take their own initiative to include human interference in the carbon cycle and then expand from there into the implications of long-term changes, lessons on anthropogenic climate change are completely omitted[1].

The curriculum does include a lengthy definition of "climate" and explicitly covers all the static conditions and "dynamic processes" that affect it – except human. When climate is discussed, the curriculum states: "Global climate is determined by energy transfer from the sun at and near the earth's surface. This energy transfer is influenced by dynamic processes such as cloud cover and the earth's rotation, and static conditions such as the position of mountain ranges and oceans" (NSES, 2007). Nothing

[1]For more complete information on the goals and content of the earth and environmental science course, go to www.learnnc.org/scos/2005-SCI/EESC/, the North Carolina Course of Study website describing the class.

more is mentioned about the compelling scientific evidence showing that humans are directly influencing the climate.

On the other hand, the National Science Education Standards focus on problem solving while keeping in mind the importance of "cost, risk, benefit analysis, and aspects of critical thinking and creativity" (NSES, 2007). This is an important concept to learn so that students can more accurately filter information they hear from media, politicians, and scientists about the debates that remain on the topic of GCC. The Science and Technology section also offers background information to help students understand the science of global climate change when or if it is presented to them. This section includes interesting comments on the importance of understanding the difference between science and technology, and why it is important to understand how one drives the other. Within the NSES there is a discussion of human change in the environment. All of the literature here deals with society out of its environmental context, however, and at one point states explicitly that progress for society is a worthy cause in itself. The general message here is that, "changes in the environment designed by humans bring benefits to society, as well as causes risks" (NSES, 2007). The effects of "progress" as a cause in itself can of course be dangerous in terms of resource extraction and environmental externalities. The messages that students glean from this section is left up to individual teachers.

Unfortunately, the NSES are significantly outdated. The most current edition's "references for further reading" section on "Science and Personal and Social Perspectives" does not reference any resource newer than 1993. At that time, the science of global climate change was in its infancy. In fact, the entire reference list for the NSES does not include *any* materials published after 1996, eleven years ago.

Many supplemental resources do exist for North Carolina teachers. At the state government level the Office of Environmental Education has published a Teachers' Guide to Environmental Education Programs and Resources. It outlines professional development opportunities for teachers around the state, as well as environmental educational support materials, education materials that teachers can order or find online, and EE field trips and site visits. Of the 102 programs and resources listed in the guide, however, none focus explicitly on teaching or learning about GCC. At the independent level, programs such as the non-profit resource called "Using the Outdoors to Teach Experiential Science" (UTOTES) are available for teachers if they search for it[2].

How Curriculum is Translated into the Classroom

According to Dr. Eleanor Hasse, the Secondary Science Consultant for NC public schools, the fact that there is no federal standard for environmental education is a significant problem because there is no minimum standard coverage of any environmental issue. Consequently, textbook content and quality varies widely, and each school can individually choose which textbook it will order. Lessons on the environmental effects of global problems like climate change are covered in some textbooks, but to different extents. "Some teachers have to have two textbooks because one is focused on each subject. Textbook makers have a national market, but only four states have earth science" (Hasse, personal communication, 6/17/06). Teachers can present the material in a variety of ways, but many of the textbooks that do cover climate change consider it an unlikely scenario.

[2] UTOTES is a fee-free educational project designed to improve elementary education. See Appendix Two for more examples.

Textbook publishers want their textbooks adopted and are generally risk-adverse in their design, specifically avoiding statements that a few individuals on a textbook selection committee might find problematic. They tend to stress the "debate" of climate change rather than focusing on the scientific consensus that does exist (Prentice, 2006). This is made even worse because the textbooks, and therefore the science information taught, are outdated. Most teachers are still working from 1999 documents. For a dynamic topic like GCC with updated information appearing frequently, this can be problematic for educators.

Prentice, a popular textbook publisher in North Carolina, offers a new program called "event-based science" to supplement textbooks. Teachers can order lesson plans for teaching about special science issues through hands-on activities. Only one optional supplement called, "Global Warming? Investigations on Climate Change" explicitly addresses climate change. An optional add-on to this lesson is entitled "Science Explorer: Weather and Climate and Event-Based Science: Hurricane!, Tornado!, and Global Warming? Value Pack" (Prentice, 2006). Textbooks like these emphasize the lack of certainty not only in what varied and unpredictable climatic changes will happen, but also in the science itself.

Since the earth/environmental science class for many schools still has not become a part of the curriculum, students only receive information on issues like climate change from other courses. AP Environmental Science is offered in some high schools, and devotes many of the lesson plans to ecology. Global climate change is addressed in more detail here, but only a limited number of students have time for the class in their schedules. Even at more progressive and well-funded schools like East Chapel Hill High

School, where the earth/environmental science class has not been added, science teacher Judy Jones says her Biology I class is the "only taste all kids get of climate change" (Jones, personal communication, 11/16/06). This freshman level course is organized around the concepts of ecology, and has a small section on the basics of climate change and other anthropogenic environmental problems.

Experiences of Teachers

Experiences in the classroom are the true test of how students learn about global climate change in a formal setting. In an effort to evaluate the state of affairs in local schools, I interviewed several science teachers in nearby counties. Jarrod Dennis teaches earth/environmental science, which is required at Middle College High School in Durham. Dennis reports that there is a list of textbooks that the state curriculum board has approved, and that the district school board votes on which one of these to use. Glinko's Earth Science, Geology, Environment, and the Universe was chosen recently and he says it "does a good job with climate change" (Dennis, personal communication, 11/20/06). This publisher sends inserts every year to update its science textbooks, which the teacher can then incorporate into lesson plans. Dennis has taught this class for six years and says that the content has stayed the same as long as he's been teaching. He generally uses yahoo.com and msn.com to supplement the textbook, and says that there is enough information online available through these resources. He tries to use current events to make the science more applicable to students' lives. He doesn't use prescribed curriculums or government-provided supplements, but is aware that the state board of education is trying to add an end-of-year test, so he expects that the curriculum will

become more standardized over the next few years. Because Dennis has a degree in science, he uses the information he learned in college instead of pre-made lesson plans. Many of the teachers I spoke with at North Carolina public schools had never heard about the certification program. One stated that the administration tends to be "lackadaisical" about informing teachers about certification programs.

Judy Jones uses Prentice Hall's "Biology" book by Miller and Levine. Jones calls it an "excellent book with good authors." She chose it over the state book that was recommended for the class because she knew that one of the authors, Ken Miller, was an outspoken advocate for teaching evolution during the 2005 Dover case on evolution. Jones only uses the internet sparingly, and was never trained on the subject of environmental science (Jones, personal communication, 11/16/06).

Challenges of Teacher Education

The experiences of Judy Jones and Jarrod Dennis that I report seem to be common among environmental science teachers. There has been much debate about how teachers can be properly trained to teach the new earth and environmental science class; most teachers have not been trained before they are assigned to teach the subject. Research on teaching methods and effectiveness is extensive and it is well documented that the extent of a teachers' prior knowledge of a subject is a major factor that affects what students learn. Waters' (2003) study on how children learn about the "nature" of science (the fundamental science knowledge and concepts of how science is practiced, used, and why it has become the way that it is) claims that no matter how complete the teacher's background is in science, students won't necessarily show fluency in the nature of

science. The study shows that "teachers' conceptions of the nature of science do not necessarily influence classroom practice" (Waters, 2003, p. 927). In other words, even teachers' positive experiences and ideas about the importance of science does not necessarily translate into lessons that cause students to better appreciate science and nature. According to this study, such appreciation is created through experiential learning that cannot be solely gained from a textbook in a classroom. This study suggests that more is needed than "simply teacher training. The clear implication is that a teacher's efforts at implementing the earth and environmental science class without even basic training will be regrettably inadequate. At the very least, substantial teacher training is needed for adequate student understanding of the nature of science.

In addition to more teacher education, lessons on understanding the basic nature of science must be translated into classroom activities. However, incorporating these kinds of activities into a classroom is time-consuming for teachers and can be expensive. Many education analysts agree that, "At this point, there are limited practical suggestions available to classroom teachers for promoting students' conceptions of the nature of science" (Waters, 2003, p. 927).

Even with substantial effort toward enacting theoretically meaningful changes in curriculums, actual implementation of new science standards is a difficult task. Ultimate success depends on how teachers interpret curriculum mandates and implement changes in their classrooms. That implementation will be strongly influenced by the teacher's training and subject-matter expertise. No matter what legislation is enacted on the national level, "Teachers will ultimately decide the fate of national and state science standards" (Bélanger, 2003, pp. 401-402). One study on the implementation of new

environmental education policies in Michigan showed that despite the radical thrust of the new education framework, teachers tended to base their changes in the classroom on familiar ideas and ignored ideas that did not fit in with their existing beliefs and knowledge structures (Spillane, 1999, p. 405). Old frameworks were so ingrained that even strongly proactive efforts to change them were unsuccessful. These problems must be addressed both nationally in terms of policies and funding, and locally in terms of effective teacher training.

Quality Environmental Education

The environmental education system in North Carolina is troubling in terms of effectiveness and relevance. Basic compositional problems exist in the science curriculum. It does not provide the tools necessary for what educational theorists call a complete science education. Proper education must include hands-on experiences for students, provide real-world applications, highlight the relevance of science in other contexts, and be flexible enough to account for the diversity of student backgrounds and experiences (Bélanger, 2003).

There is an agreement among both researchers and the stated goals of the state science curriculum that the principal aim of education should be to "enhance the ability of children to become productive members of society" (Hudson, 2001). It is by teaching children active participation in their community and stewardship of natural resources that society is most likely to benefit from environmental education. David Orr (1992) states that in order for our populace to be scientifically literate, no student should be allowed leave school without basic comprehension of the laws of thermodynamics, the basic

principles of ecology, carrying capacity, energetics, least-cost and end-use analysis, the limits of technology, appropriate scale, sustainable agriculture and forestry, steady-state economics, and environmental ethics. Students should know the difference between what *should* be done and what *can* be done, and the distinction between optimum and maximum in terms of environmental resource use (Orr, 1992).

It is possible for students to get the kind of education Orr advocates formally in school if the school uses activity-based learning strategies. It is difficult, in this test-driven "No Child Left Behind" era to formulate a curriculum that incorporates some of the ideas presented by Orr and Bélanger. Problem solving, leadership, and genuine participation are almost universally accepted as positive behavior, but it is difficult to test for this formally. This means that education with the goal of explicitly instilling this behavior in students is overlooked. These types of goals are mentioned in the theoretical outline of the state curriculum, but practical applications are usually not echoed in state-supplied lesson plans.

Many education specialists say that the goal of environmental education should be to promote "environmental literacy" in the student. This concept came from the work of Charles E. Roth in the late 1960s (St. Clair, 2003, p. 69). Roth defined it as

> …the capacity to perceive and interpret the relative health of environmental systems and to take appropriate action to maintain, restore, or improve the health of those systems…. Environmental literacy should be defined… in terms of observable behaviors. That is, people should be able to demonstrate in some observable form what they have learned – their knowledge of key concepts, skills acquired, disposition towards issues, and the like. (cited in St. Clair, 2003, p. 69)

Environmental education theorist David Orr (1992) describes environmental literacy as "the ability to ask 'what's next?' when making decisions likely to impact the environment." Orr laments traditional education, which he claims teaches students how to

more effectively exploit the earth of its resources. He states that real learning is described as something that increases intelligence, or "the ability to call things by their right names" (Orr, 1992). When taught effectively in a classroom, environmental literacy has the potential to change the ways that environmental issues are conceived. Students should be encouraged to ask questions about "the implications of current structures in science" (St. Clair, 2003, p. 71). This kind of learning can lead to more creative solutions for environmental problems, as well as a deeper understanding of their complexity.

Although formal education is not the place for politically-charged environmental activism, environmental literacy is also required for effective environmental advocacy. Civic action and local empowerment have historically had an impact on environmental successes. Students of formal education should learn that civic action is important in protecting the environment and stopping or slowing environmental problems like global climate change. This kind of education also belongs in social science curriculum. "Instead of viewing literacy as a state attained through the ingestion of sufficient knowledge, I have argued that it represents a set of social practices" (St. Clair, 2003, p. 77).

Dr. Paul Bélanger (2003), an environmental education researcher who studies ways to create socio-environmental change, suggests that schools should shift to more hands-on strategies of EE. Relying only on top-down strategies of information transmission on environmental issues is ineffective. People need to be educated about things that they see in their daily life. In addition to strong adult environmental education campaigns, Bélanger claims that,

> …educators must participate in real-world activities and work with local people to create concrete, constructive action. Alternative environmental adult education

> leads to changes in educational practices by dealing with both the cognitive and affective dimensions of genuine learning, by allowing for transfer of knowledge from children to parents and vice-versa, and by allowing actors external to the community to intervene and relate scientific knowledge to current, local issues in a way that respects local knowledge and peoples. (Bélanger, 2003, p. 86)

When examining environmental education in this framework, some basic problems can be found in all state curriculums. For example, because national environmental education is housed in the science curriculum in public schools, there is an assumption that *only* scientific knowledge is needed in order to be environmentally literate. This emphasis on scientific understanding also "enshrines Western science as the primary means for humans to engage with the environment" (St. Clair, 2003, p. 72).

Following this line of thinking, in what discipline would things like health consequences of environmental decisions be taught? Environmental ethics? "Curricula often collapse back into individualistic and economic concerns. To the degree that they do collapse in this way, they counteract the push for critical action at the center of environmental literacy" (St. Clair, 2003, p. 72). David Orr claims that all education is environmental education. Teaching economics without including thermodynamics and ecology denies their important links to the economy (Orr, 1992). Full environmental education should be combined with history lessons on environmental issues, an understanding of the role environmental problems play in current events and world conflicts, and the economic implications of limited resources. Other improvements could include adding books like A Sand County Almanac in the English curriculum, making environmental history a standard part of American history, making sure that students are educated on environmental issues in the political science and current events classes, or including outdoor education settings into general curriculum requirements.

According to Bélanger (2003), EE is now slowly becoming more accepted as a standard part of education. However, acceptance in the curriculum is not sufficient; the right kind of environmental education is vital and the only way for it to be effective is if it is taught in the right kind of "learning environment" (ibid). Learning environments must be interactive and reward creativity. This kind of participation in one's education will actually improve cognitive development and is more likely to be life-long (Bélanger, 2003).

Bélanger's strategy aims to synergize formal and informal education to help students see past what he calls the "hidden curricula" in the present education system (Bélanger, 2003, p. 79). The present system uses information that has not been formally revised in decades. As seen in the history of the Environmental Education Acts, profound changes are frequently blocked or diluted as they pass through review process after review process. In our rapidly changing world, it is not safe to assume that this knowledge base will remain relevant throughout life (Bélanger, 2003). For these reasons, potential shifts in teaching methods tend to be very limited.

Despite the way traditional ideology may be severely limiting education, it is generally believed among environmental theorists that learning can be more effective if schools shift from transmissive forms of learning to being more reflexive. Curriculum designers must keep in mind that "learning depends on social interaction; conversations shape the form and content of the concepts that learners construct. Only part of specialized knowledge can exist explicitly as information; the rest must come from engagement in the practice of discourse of the community" (Roschelle, 1995). Progressive policies backed by real resources can encourage teachers to combine their

lessons with experiences students are getting from other aspects of their education. This way, learning is long-term and more likely to be effective and memorable (Roschelle, 1995). An additional complication is the fact that learning environments are not neutral. "Institutional pedagogies" remain unquestioned in most educational settings (Bélanger, 2003, p. 81). "New pedagogies of environments are needed to bring to life people's cultural environments, enhancing the involvement of people … in the critical assessment of their daily surroundings" (ibid).

Along with an enhanced focus on putting science into context, educators need to be sensitive to the role of diversity in modes of learning: "the way most people understand science and nature are inevitably and fundamentally shaped by their gender, ethnicity, religious background, socioeconomic status, geographical location, and so on" (St. Clair, 2003, p. 74). Because students come from diverse backgrounds, the curriculum should "include elements of the learner's experience and attempt to recognize diversity as widely as possible" (St. Clair, 2003, p. 75). Income differences among students and teachers, for example, lead to different ways of understanding the costs and benefits of conservation. Students who live in poverty are unlikely to buy locally grown produce no matter how well they are educated because it is simply more costly and usually not found in low-price supermarkets. Additionally, "some of the assumptions behind environmental literacy, evolution for example, may contradict religious teachings and cultural narratives. Finding a way to connect across diversity is both difficult and essential to the creation of sustainable environmental literacy" (St. Clair, 2003, pp. 74-75). More examples of positive environmental education strategies are described in chapter four.

A very basic compositional problem exists in the public school system in the United States. Standard review processes are sluggish and time-consuming. In many cases, very simple changes can take years to implement. There is a need to improve how the entire process works during the curriculum review process. Other organizations, like the federal geographic data committee, offer examples of ways that school board changes can become more streamlined. The geographic data committee has a peer review board that is constantly responding to suggestions about new material. This kind of board in an education framework can ensure that the information students are learning is scientifically current. Speeding up this process and making it more streamlined, however, does not address the difficult problem of teacher training. Changes require enormous funds for the process to work smoothly and efficiently, while keeping the needs of students and teachers in mind.

EE Examples in Other States

Other states are faced with the same obstacles as North Carolina, and something can be learned from the way that other states face these new challenges in science education. The Yale Project on Climate Change (2006) suggests that states take advantage of the required fall 2007 reviews of science standards to make positive changes. New consideration must be taken regardless to prepare for the start of "high stakes" science testing under the "No Child Left Behind Act" to improve K-12 understanding of GCC. The state of Colorado has taken this opportunity, and is "promoting (GCC) as a standards-based content area within science curricula and incorporating it into other disciplinary curricula and teacher certification standards" (Yale

Project on Climate Change, 2006). In other words, they are taking advantage of new school system requirements in order to make positive, fundamental changes in their curriculum. North Carolina could take the same opportunity to incorporate EE into other courses.

California has also taken strides to establish alternative methods for teaching environmental education. In 2003 the state established an Outdoor Environmental Education Program. It also provided grants to public educational agencies who serve at-risk and underserved demographic groups. This step was important because this demographic is commonly left out of environmental education efforts. Although the state depends on private donations to support these initiatives, they are steps in the right direction (de la Maza, 2003).

Other examples of reform can be found in Michigan. In 1991, the Michigan Department of Education redesigned the framework for science education in that state. Similar to North Carolina's framework, it emphasized scientific literacy, which in this case refers to "an understanding of those aspects of science that are essential for full participation in a democratic society" (Michigan State Board of Education, 1991, p. 3). It identified three components of scientific literacy: knowledge, activity, and context. The changes that came from this revised framework were rather radical and complex. Instead of a traditional emphasis on scientific knowledge like matter and energy, motions of objects, et cetera, reformers wanted students to understand the "key scientific constructs and the relations among them" (Spillane & Callahan, 1999, p. 403). Activities stressed that science is a *tool* that students need to learn how to use. Students "should learn to reflect on the science knowledge they generate and to consider their findings in light of

the social and cultural history of the scientific community" (ibid). This is a fundamental change from the focus of the previous curriculum. Here, science is "about posing questions, justifying and critiquing findings, drawing conclusions, and reflecting upon the limits and consequences of these conclusions" (Spillane & Callahan, 1999, p. 404). The focus was changed from basing science education on students' prior knowledge of scientific ideas to reconstructing their existing knowledge of that idea (ibid).

The efforts described in these examples are still in progress and suit different school systems to different extents. Much work needs to be done to decide what would work best in North Carolina, given our unique demographics and resources. Ironically, the problem remains that only a more educated public would feel strongly that a strong education system is needed to teach climate change. Formal education is of course only part of what is needed on a larger scale in order to lead to meaningful action to stop or slow global warming, but it is a major building block to help create effective change.

Conclusions

A restructuring of the basic educational framework may be needed for environmental education to be truly effective and for students to become environmentally literate. However, with more research, and the willingness of educators at the local and national levels to be creative, smaller changes can lead to real differences. Taking demographics and differences in personal experiences of students into account, integrating new sources of information into the curriculum, and providing solid teacher education are all positive steps that will help create future environmental advocates and problem solvers (Hudson, 2001).

The following chapter looks at where the public is learning about global climate change. It especially looks at the roles of media and scientists in framing the public debate over how to respond to threats associated with global climate change.

Chapter Three

Public Perceptions of Climate Change

Scientists and researchers around the world are currently working to improve scientific understanding of the causes of global scale climate change. Supercomputers are at work 24 hours a day, trying to predict the impact that anthropogenic forces will have on earth systems. Millions of dollars are spent on design and execution of this research and on new technologies to curb climate change. However, little attention has been given to a very important and complex factor in the enormous effort to stall the negative effects of global warming: the attitude and understanding of the citizens of the United States. With over 280 million people, the US is only four percent of the World's population yet uses 25% of its oil resources (Leiserowitz, 2007). Because this country alone produces more greenhouse gases per capita (6.6 tons per year) than any other country, it is especially vital that United States citizens participate in any new policies (EPA, 2005). Individual lifestyle changes in this country could mean a huge reduction of world levels of greenhouse gas emissions.

Public awareness and understanding of global climate change is only now becoming mainstream. Because it is not yet incorporated into the public education system in a meaningful way, most Americans who are aware of it are learning about it from other mediums. These mediums must be examined and better understood in order to recognize the mechanisms involved in informal climate change education. The general trend is that

the public is learning about the problem from the media, but wishes to learn about it as directly as possible from scientists who study the phenomenon (Patchen, 2006).

Some studies have been conducted to understand the quality of knowledge that most Americans now have. Unfortunately, findings are contradictory and generally outdated. According to surveys by the National Science Foundation (NSF), most Americans seem to accept climate change as a real phenomenon, but are not greatly concerned (NSF, 2007). This could be linked to a poor understanding of the issue. A recent survey by the Michigan Institute of Technology tested knowledge of the phenomenon and found that the United States public does not understand climate change and the threat of global warming (Stauffer, 2005). According to dozens of surveys collected by Patchen (2006), a large part of the public does not know that GCC is primarily caused by the release of carbon dioxide into the atmosphere through the burning of coal, oil, and gas (p. 24). Many mistakenly believe that visible "pollution" and/or the depletion of the stratospheric ozone layer are important contributors to global warming (ibid). NSF surveys (2007) found that when the public self-reports on their knowledge of global warming, most tend to have false confidence in their knowledge of global climate change. 70% of people surveyed in 2005 said that they understood it "very well" or "fairly well" (24% answered "not very well," six percent answered "not at all"). Furthermore, these numbers changed very little from the four previous annual surveys, also performed by the NSF (2007). These results show that Americans do incorrectly believe that they have a handle on climate change, and that they do not seem to learn more about it as time passes. In other words, self-perceived knowledge of the issue

(incorrect or otherwise) seems to be relatively high and consistent, despite rapid scientific advances.

Lack of knowledge of the causes and effects of climate change has been shown to correlate strongly with lack of public concern (Stauffer, 2005). This can be linked to lower participation in preventative action on this issue. A 2006 survey of Americans that controlled for educational and philosophical differences showed that the greater people's knowledge about climate change, "the more likely they were to say they were willing to take a number of positive actions… also, the more likely they were to vote in favor of a number of hypothetical referenda relevant to climate change (e.g. a higher tax on gasoline)" (Patchen, 2006, p. 24). These studies also found that most do not realize that energy efficiency and conservation are the best ways to reduce greenhouse gases, and therefore don't focus on these strategies to combat climate change. This was shown to be the case in a 2004 survey by the NSF that asked what environmental hazards Americans were concerned about. Out of a list of ten types of issues, "greenhouse effect" or "global warming" ranked ninth (NSF, 2007). Because the public doesn't understand the major causes, most people either offer only vague solutions to the problem or endorse solutions that would be ineffective, like promoting recycling and managing hazardous waste.

Despite the current absence of public demand for policies that could combat climate change, 96% of Americans said they were sympathetic to environmental values The same 1995 study showed that 35% said they cared enough about the environment to change their shopping decisions, and 20% of Americans called themselves active environmentalists (Beder, 2002). At the same time, however, the government is rolling back environmental regulations that have been held in place since the 1970s. This

disconnect has frustrated environmental activists. One explanation could be that most Americans see no division between their values and the actions of policy makers because they simply trust that politicians would not roll back important environmental protection. Most people assume environmental problems are being cared for. Furthermore, accurate reports of these rollbacks are often discounted as negative and partisan reporting (Cox, 2006).

Although many people trust only what they consider pure "science" and want to learn about climate change from scientists, most people hear about it second hand through reporters. At this point they must rely on how accurately research is translated by members of the media. For this reason, media have been an important but controversial source of information on this issue (Patchen, 2006). The following sections will discuss how the complex partnership between media sources and climate scientists affects informal public education on global climate change.

Media

No matter what technology scientists and researchers may find to fight against global warming, any meaningful change requires legislative action, which in turn needs the support of an educated public. Unfortunately, there are few credible sources that can accurately represent the complex interaction of climate with earth systems. Work by the Nicholas School at Duke University has looked at how to build public consensus on the

issue, and the North Carolina Climate Change Science Partnership[1] has recently studied public understanding. Both found that the news media has a profound effect (Lucas, 2005). Now that internet and television are almost ubiquitous in American homes, the media plays an ever-increasing role as an educator. With such a highly politicized topic, bias is sometimes present and usually suspected. Because accurate public environmental knowledge is vital, the role of the media must be carefully understood.

Media has historically played an important role in American democracy. It serves as a watchdog to keep the government working in the interest of the American people, as a gatekeeper of information, and can be a fundamental voice of environmental concerns. Many Americans base their opinions with respect to the state of the environment on the news (Cottle, 2000). Those concerned with public environmental education believe that the media can become a better mechanism to make people aware of the urgency of altering their behavior so as to reduce the degree of climate change. Media attention and weather fluctuations have been cited as two of the main factors that influence public concern (Bord et al, 2000, p. 205). In early 2006, a group of journalists and writers from Britain, Germany, and the United State met to discuss the failures of environmental coverage in the media as well as possible opportunities. They found that although "more newsprint, broadcast time and web space is being devoted to the issue of climate change than ever before," the public is doing little to take action against climate change (Retallack, 2006, p.1).

Unfortunately, media are not always reliable sources. Studies compiled by

[1] The North Carolina Climate Change Partnership group promotes collaboration between research scientists and science education centers to provide opportunities for the public to learn about climate change science. For more information, go to http://www.sustainer.org/pubs/ncclimate.pdf.

Patchen (2006) from all over the world have shown that media tend to report on the most catastrophic and sensational stories (p. 33). For this reason, media coverage of global climate change faces two main obstacles in terms of providing clear, accurate representation to the public. Firstly, because there are so far few examples of dramatic, physical evidence that can undoubtedly be attributed to human-induced climate change, it is underreported. Gradual, long-term changes due to GCC are less dramatic and therefore usually overlooked. Secondly, when it is believed that GCC has contributed to a catastrophic event, reports tend to overemphasize the extent to which GCC can be definitively blamed as a cause. Claims like these can be easily questioned. The result is that the public has become more confused and less trustful of media coverage (Patchen, 2006, p. 33).

Perhaps a fundamental problem with education delivered by television or print media is the fact that these information sources (other than public media) are owned by corporations that are simultaneously trying to sell something. Because almost any climate change policy in this country would require that Americans change their habits, many industries could be negatively affected. It is important to note that the situation is improving slowly, and more and more corporations are beginning to incorporate climate change mitigation into their business plans (Mathews, 2007) However, some still have an interest in maintaining the status quo, which sometimes means choosing which stories are reported and which are not. Think tanks and front groups funded by corporations are eager to supply information to journalists researching a story. Because controversy creates interest, “Those who have sought to cast doubt on global warming and ozone

depletion have found a ready audience in environmental journalists at some of the top newspapers" (Beder, 2002, p. 200).

Many reporters have little time to research complicated background information for breaking stories, leaving room for oversights. There is no equivalent to "libel" for scientific research, and journalists are only superficially held accountable for mistakes they make. Reporters citing scientific evidence do not have to investigate or report whether the information that they are presenting has been peer-reviewed. They also are not required to mention if a scientist quoted as a source was also a consultant to industry.

When the media begins to act in the interest of its own or its advertisers' bottom line, the role of media as a source of reliable information providers is threatened. Broadcast corporations have an incentive to discourage journalists who report on politically charged environmental issues, like climate change, that make advertisers uncomfortable (Achbar, 2004). Effects of questionable sources of information mixed with possible corporate interest could cause the media to misinform the public, thereby threatening efforts to pass climate change legislation.

Often, the difficulty with presenting science to the public via television or even print media is that environmental journalists must compete with other issues that contain more dramatic visual images and attention-grabbing details. "Although the environment may be an important concern, news media are pressured to underreport environmental problems or cover them in highly dramatized ways" (Cox, 2006, p. 164). There is very little room left to cover environmental stories, especially if they are complicated. Instead, reporters must find an event to hook onto to make a topic newsworthy. Hooked onto a more captivating event, coverage of the environmental aspect of an issue is kept as brief

as possible. A dangerous result of these truncated news stories is that viewers feel they have sufficient information after only viewing a short news clip of a simplified version of climate change. This trend of shortening complex issues into sound bites allows misleading policies to pass, such as the Clear Skies Initiative. This policy will not lead to "clear skies," but was named with the knowledge that most voters will read no further than the title, allowing it pass with less opposition. This trend is supported by a series of studies of avid televisions viewers in 1999. They "found that exposure to environmental stories generally left these individuals *less* knowledgeable about environmental issues than were lighter TV viewers, as well as more fearful about specific environmental problems" (Dunwoody, 2007).

A full picture of what is happening is particularly difficult to obtain, especially given the fact that the journalists are encouraged to keep these stories to an eighth grade reading level[2] (Meyer, 2004). Efforts to translate and simplify information risk skewing the actual implications of research. Reporters are forced to edit and reduce complex environmental issues, creating confusion and the misinterpretation of information. This further convinces the public that the subject in question is only "a vague possibility rather than a looming threat" (Cox, 2006, p. 189). On the other hand, according to the NSF (2007), much of the public is aware of these deficiencies and no longer trusts news media to correctly educate them on environmental issues. A 2005 NSF survey found that only 29% of the public thought that news coverage of global warming was generally correct.

[2] Well-known UNC Chapel Hill Professor, Phillip Meyer, says that this level of reading is the "sweet spot" for selling newspapers. This strategy assists in what he calls the main goals of a newspaper: sales and influence.

Public television and radio are important exceptions to the challenges faced by traditional media. They are able to devote more time to the subject, and can go past the standard format in which opposing "experts" voice sound bytes in a 60-second spot. "Public television can present a 60-minute program that not only includes that scientific debate, but also adds other necessary details to help the audience understand the political and scientific context of climate change" (Wilson, 2000, p. 213). Such a program would never be able to win competitive airtime on a television station funded by advertisers.

The role of television and print media as an informal yet influential educator about climate change can be problematic if it contributes to the American public's already poor understanding of climate change. The problem is compounded by the effects that television is having in general on American society. People who watch more than two hours of television a day are less likely to think that climate change is a threat to their lives, or believe that it is their duty to protect the environment (Cox, 2006, p. 190). This shows that high exposure to news reports about the environment won't necessarily lead to a stronger environmental ethic.

An interesting 1998 survey illustrates that the effect of television and print media can be complex (Patchen, 2006). During the time of the Kyoto Conference on Climate Change, a survey of Seattle residents found that as exposure to the issue in the media increased, the proportion of Americans who read or heard a media story went up from 38% to 50%, and knowledge of the causes, effects, and solutions to global climate change increased accordingly (Patchen, 2006, p. 34). However, reactions to this knowledge differed depending on political affiliation.

> Democrats became <u>more</u> likely to support strong actions to combat global warming (which prominent Democrats had been advocating) while Republicans

> (whose party leaders were opposing such measures) became less likely to support these actions than they were before the greater media coverage began. This result is consistent with other research findings that show that people tend to react to media messages, including those on climate change, by fitting them into their previous views. (Patchen, 2006, p. 34)

Another common response to media coverage of GCC is immobilization. Polls show that the more people are frightened with images of catastrophes that will happen from global climate change, the more they are likely to tune out the information altogether (Patchen, 2006). The common ways of depicting the effects of climate change (droughts, floods, famines, diseases, sea-level rise) often contributes to the feeling that there is nothing that we can do to solve the problem. "When GCC is depicted as 'scary weather' it evokes a 'weather frame,' and is thus outside human control and even human timelines" (Patchen, 2006, p. 35). Rather than stressing the overwhelming consequences, researchers suggest that positive GCC education would involve making people aware that if action is taken quickly, we have a real chance of either stalling or stopping it from occurring (ibid). A further discussion of educational information that leads to positive changes in behavior is found in Chapter Four.

Scientists

Because media sources can be unreliable, many people look to scientists for accurate information about global climate change. Ostensibly, the role of scientists in public education on GCC is central. Many politicians, members of the media, and scientists alike raise the status of science above all other authorities, and behave as if the only restraint to reach the "Truth" about GCC is the current level of technology or quality of science performed. In this way, science has a strong symbolic legitimacy; we can test

it and endlessly evaluate results – there is an assumption that we can trust what it tells us. The issue of how climate change is portrayed to the public is, of course, not this simple.

Historically, efforts to warn the public about the dangers of climate change have not been successful. When mainstream scientists first became concerned about global climate change in the 1980s, they tried to make the public understand the urgency by expressing that we were feeling the effects of warming at that time. As it happened, the summer of 1988 was one of the hottest summers on record in the United States to date. Uncontrollable fires were devastating Yellowstone Park, and a major drought was plaguing the Midwest. The public was paying attention, and scientists and global warming activists "could not resist taking advantage of the spike in United States' temperatures" to get the public to make the link to GCC (Palfreman, 2006, p. 29). James Hansen of NASA's Goddard Space Center testified in front of Congress that year and warned that global warming had already begun. Unfortunately, his use of the term "global warming" and his dire predictions for the immediate future were problematic. The term "warming" was too simplistic and didn't account for the many other problems associated with GCC. Additionally, the next few summers were considerably cooler. Looking back, his predictions were premature and possibly contributed to the current public opinion that global climate change warnings are blown out of proportion (Palfreman, 2006). After this happened, many tried a new approach to public education. "Climate scientists have struggled to communicate a much more nuanced picture of the issue – a kind of Climate 101 – while maintaining a sense of urgency" (Palfreman, 2006, p. 29). This new approach is complicated and multifaceted. For example, scientists now present anthropogenic carbon dioxide as the main culprit of global climate change.

However, in an attempt to explain the larger picture of how the earth's climate functions, carbon dioxide is simultaneously explained as only one factor among the many that push and pull the climate. The fine distinctions have proven to be too complex for most journalists to address and are "…far too convoluted to be encapsulated in a sound bite or icon" (Palfreman, 2006, p. 29).

This challenge is further complicated by some of the basic limits of science. Science can sometimes lead to ambiguous results that don't give the "yes/no" answers that people usually like to hear. It is the nature of science that many experiments yield further questions and discover new variables. A common example of how science can be inconclusive is in the case of how cloud cover will change as the climate changes. Supercomputers have been busy for years trying to understand what role cloud cover might play in the coming years if carbon dioxide levels continue to rise due to human activity. Predicting cloud formation, however, is much like predicting the way a single leaf might flow down a stream (Flannery, 2005). Currents might take it in different directions and its path cannot be predicted no matter how well stream flow is understood. This and other factors lead to a general lack of specific predictability in GCC, but not a lack of evidence that global climate change is real and very dangerous.[3] This is a difficult

[3] Reasons for lack of predictability include: (1) Changes in one greenhouse gas concentration indirectly cause other feedbacks, thus yielding additional changes. (2) Water vapor and cloud formation are the largest sources of uncertainty. (3) Anthropogenic aerosols due to industrial activity and biomass burning reflect incoming light, absorb some infrared radiation, and serve as condensation nuclei for clouds. In general, they cool the planet but are washed out quickly by rain and snow. (4) El Nino is chaotic and has a longer time scale. (5) It's difficult to tell the difference between chaotic natural variations (seasons, volcanoes, variations in solar output, and Milankovich cycles) and forced anthropocentric variability.

message to relay; often, questions about specifics of GCC can be translated into general doubt that it will occur.

Scientists can only provide data to inform politicians about an issue. Because of the nature of science, research usually does not point to a specific policy but must be interpreted by policy makers who have specialized skills and can keep the reality of culture in mind. In cases where acceptable risk is questioned, it is politicians, not scientists, who must make the final decision. Because politicians are not trained scientists, they often need data interpretations to be made for them. Industry can easily take advantage of this moment and make scientific results appear universally questioned. The same data can be used to support a precautionary view that requires immediate restrictions on greenhouse gases, while also supporting a policy that fosters a more "wait and see" approach. Industries who might suffer from increased restrictions of greenhouse gas emissions usually urge caution and advocate the "wait and see" approach. This trend goes against the "precautionary principle," which states that the danger of possible harm is greater than the benefits of continuing with behavior (Steingraber, 1997). The precautionary principle requires action to prevent harm and eliminate hazards. According to this principle, a polluting industry should take immediate action if environmental harm is even possible. Whenever an activity raises threats of harm to human health or the environment, precautionary measures should be taken, even if some cause and effect relationships are not fully established scientifically. The question of whether to take a precautionary course or to take the course that is most economically advantageous is usually the basis for conflict over climate change mitigation politics.

Misrepresentation of scientific data is unregulated, yet has profound effects on the public, their votes on policies, and therefore on environmental degradation. As mentioned above, there are currently no guidelines to monitor what journalists are allowed to report on the nightly news. Reporters are expected to present both sides of a story, and sometimes strive to do this, even though dissenters of climate change science are almost universally discredited. The representation of opposing viewpoints can indicate that there is significant conflict among scientists when there is none. In fact, "consensus as strong as the one that has developed around this topic is rare in science" (Romm, 2002, p. 12). To make matters worse, news stories in the past have included global climate change dissenters contrasted with scientists whose views are even more extreme and whose predictions are more severe than the majority of scientists (Flannery, 2005). In this way, the media can amplify the view of extremists on both sides of the issue. When neither scenario plays out, scientists in general are discredited. Fortunately, this trend is changing in favor of ignoring climate change skeptics and presenting finer distinctions among mainstream science.

Science is further limited by ideology, government budgets, and funding by outside sources. It is no coincidence that industry-funded research on GCC often has different results than research funded by NASA or Greenpeace. Even scientists who are funded by impartial sources usually know who the biggest challengers of their research will be as soon as they understand what their research findings and recommendations might say (Cox, 2006). This pressure must not be underestimated. "Agency officials have sometimes ignored or misrepresented scientific findings to placate the criticism from regulated industries" (Cox, 2006, p. 338).

When this occurs, there is a sort of paradox. Industries use science to cast doubt on GCC and justify the safety/legitimacy of their actions and at the same time dispute new unfavorable science at every step. The question arises of *whose* interpretation of science wins. This is when the struggle for symbolic legitimacy is fought[4]. Many industry spokespeople evoke a "trope of uncertainty" that "reframes a claim to alter its meaning or changes our understanding of a statement" (Cox, 2006, p. 345). This can be achieved by questioning part of the research to overshadow a more general finding, or by simply declaring that the science is inclusive. Both strategies ignore the nature of scientific inquiry and the accurate data that science does provide. This can stall ameliorative action. It also goes against the precautionary principle and implies that "the proponent of an activity, not the public, should bear the burden of proof" (Cox, 2006, p. 341).

Because of the power of the market in the United States, science usually does not interfere with the economy unless there is proof that a product is harmful. In cases where industry claims that its actions do not harm the environment, it is often left up to the strained budgets of environmental activists to prove beyond doubt that a behavior is harmful. This is even more difficult because of the fact that scientific evidence is often unclear. Industry representatives can take this opportunity to cast doubt on the need for any action until there is more research to confirm the need. This attacks the legitimacy of caution, and indicates that a polluting industry's agenda is acceptable until there is "sound scientific" evidence otherwise. In this way, the precautionary principle is actually turned upside down, into a discourse to favor industry. In the interests of "protecting our

[4] Symbolic legitimacy is described as the "perceived correctness, authority, or common sense of a policy or an approach to a problem relative to other competing responses" (Cox, 2006, p. 333).

economy," even "our way of life," industry tells us to be careful before acting too rashly. Controversy also serves to move debate out of the public realm and into the technical realm away from public awareness and easy access.

The tug of war between industries that fight to pollute and the citizens whose best interests are at stake is still happening. To Americans, who tend to believe that science is absolute, these constant reversals and challenges are confusing and downplay the evidence that science has been able to provide. Many still remember when, in the 1970s, there was talk that climate change meant that cloud cover would increase, block UV rays, and ultimately cool the planet. Science has improved since then and we now know that this scenario is unlikely. To an outsider, however, new evidence that the planet will warm is therefore also cast in doubt. Many scientists cite this past confusion as a reason to stay out of the public eye and leave it to public educators to teach about global climate change. Some worry that advocacy could further taint their credibility.

Scientists who have taken special steps to warn of the danger of GCC have faced tough opposition. Dr. James Hansen of NASA, who spoke out about global warming in 1988, has since claimed that the public debate has become so oversimplified that it is meaningless. After he helped it enter into the public/media sphere, he was immediately censored and later resigned. Industries attacked him because they feared his public awareness campaign would lead to an international treaty (Emanuel, 2007). Some pressure comes from the government as well. In February of 2007, the Fish and Wildlife Service issued a memo banning all American scientists from formally discussing polar bears, climate change, or sea ice at international meetings without express clearance to speak on those topics (Kay, 2007).

The role of scientists themselves in this debate is controversial. Historically, the scientific community has drawn a strong line between scientific findings and policy recommendations. This has helped to keep bias out of their research. Even climate scientists who might be interested in getting the message out about the urgency of their work might feel that public speaking is too difficult, that they do not know how to frame the message, or can't commit enough time (Cole and Watrous, 2007). However, many within the scientific community want to stop the trend of scientific censorship and absence of scientists in the public sphere. Many scientists are alarmed at the lack of intelligent debate on the issue of global climate change. The climate of the 109th Congress and others before it made many scientists frustrated that their research was being ignored altogether. The looming threat of GCC has convinced many scientists that they now have an ethical duty to enter the public sphere and serve as advocates for certain science-based policies. One frustrated geologist responded to the Fish and Wildlife censorship rule with this statement: "There is an onus on us as scientists to spread the word, talk about our research, and get more involved in matters of public policy and not let ourselves get shut down by the powers that be" (Geology News, 2007).

Many scientists agree that scientific and technical studies must assist in the resolution of these misunderstandings and controversies. The Union of Concerned Scientists was formed in 1969 to address this perspective head on. They strive to combine independent scientific research and citizen action to create practical solutions to environmental problems. It's now a huge lobbying force with over 200,000 scientist and citizen members[5]. MIT atmospheric scientist Kerry Emanuel (2007) suggested a more

[5] For more information, go to www.ucsusa.org

middle-ground approach. He asserts that scientists can individually decide how they are comfortable participating by thoughtfully choosing how they are "publishing, translating, advising, or advocating" their positions publicly (Emanuel, 2007). Other scientists have suggested civic science and the "democratization of knowledge" as a way to make sure that citizens are informed voters. This of course requires an extensive public science education, and must employ not only highly disputed science but moral values regarding the intrinsic value of nature and the rights of future generations.

Other Sources of Knowledge

Media and scientists are not the only players in the public global climate change education arena. Environmental groups all over the world play a huge part in trying to raise awareness of the causes and effects of GCC, as well as what members of the public can do to help ameliorate them. Many provide resources like education materials for formal educators, set up public forums where members of the public can learn from experts, or organize voting campaigns to support environmentally minded politicians and policies. The success of these strategies is difficult to gauge, but they certainly have an impact in terms of visibility and awareness.

Entertainment sources like televisions shows and movies are also cited as ways that the public learns about GCC. These have been shown to sometimes be the only way that certain members of the public – especially children – learn about GCC. This kind of education has many diverse effects, and is discussed in more depth in Chapter Four.

Conclusions

There is an enormous disconnect between what science knows about global warming and what the public knows about how their lives might be quickly changed in the future. Current modes of transmitting this knowledge are not working. Despite the fact that we face a looming environmental and economic crisis, there is general public apathy about measures to stop climate change.

More research must be done to expose gaps that exist between important scientific data and general public understanding, and also the modes by which these public impressions are made. Only by researching the breakdown of information can we learn how to make improvements in the environmental education of American citizens. As the Intergovernmental Panel on Climate Change concluded in 1992, "A well-informed public is essential to promote public policy on climate change" (IPCC 1992). Educators must take into account its global extent, complex and unpredictable effects, and social and political consequences in order to effectively communicate the importance of GCC mitigation. The following chapter discusses specific challenges to public education about global climate change.

Chapter Four

Challenges for Effective Environmental Education in the United States

As formal public education works on improving critical thinking skills and environmental literacy in its young students, most of the adults in this country have had little formal exposure to environmental education. The education that most adults did receive is not sufficient to provide them with the basic framework necessary to understand the language of climate change issues (Grotzer & Lincoln, 2007). Much of the information that adults have received about GCC comes from the news media, entertainment, politicians, or environmental activists. Due to these extensive education campaigns, most people in this country have heard of terms like "global warming" and "climate change," and are sometimes relatively educated on the mechanisms involved. (Dilling and Moser, 2007; Roper, 2006). Activists and communicators who aim to improve environmentally responsible behavior (ERB) in the public sphere have made huge strides in terms of public education, but still have a big job ahead of them.

A recent poll by the Yale Project on Climate Change (2007) showed that most Americans think that drastic measures to slow climate change must be taken in order to ensure that "life on earth continues without major disruptions" (Yale, 2007) This attitude is a major change from surveys taken even in the last few years. People are finally starting to believe that the earth is facing a crisis. Still, very few people are willing to change their behavior. The same survey also found that 67% of Americans are against

increasing gasoline taxes. People still believe that effects will be felt far away, and won't impact their own lives or communities (ibid). Frequently, people believe that they can do nothing to make a meaningful change, or that it's too late for their actions to make any difference (Patchen, 2006). This kind of apathy stalls remedial steps that must be taken to lessen the threats of global climate change. Cooperation from the public is needed to speed up efforts to reduce emissions and supports environmental efforts and policies that could lessen the threat of GCC.

Certain aspects of global climate change lead to it being a difficult issue to address in the public sphere. Environmental activists must keep these factors in mind as they customize the messages of public environmental education. Because the effects of GCC are not being felt presently, because the places that are most vulnerable to its effects are not in the continental United States, and because its solutions are perceived to be so costly, many people in the United States lack the sense of urgency that is needed for immediate action and lifelong environmentally responsible behavior (ERB). Because solutions to the threat of GCC sometimes threatens the power of the American market system, and because responsibility for mitigation falls on everyone, few people are willing to sacrifice now to relieve what they see as vague problems in the future. In these ways, global climate change presents unique, worldwide problems that are different from what the global community has faced in the past. The following list of challenges includes problems that are unique to global climate change mitigation efforts. Some have been discussed in more depth in previous chapters or will be discussed more thoroughly in the recommendations section. Many items are taken from a comprehensive list of problems outlined by Lisa Dilling and Susanne C. Moser in the introduction to their 2007

edition of Creating a Climate for Change: Communicating Climate Change and Facilitating Social Change.

Reasons for Apathy

While concern about global warming appears to be increasing, many, if not most, Americans continue to lack a sense of urgency regarding immediate steps to reduce greenhouse gases. Lack of urgency is in some ways explicable, given the characteristics of GCC. The following challenges listed are add complexity to the previously discussed influences on environmental education on climate change (i.e. the role of media and scientists).

1. Time Lags

Time lags in cause and effect are major roadblocks for promoting ERB. Emissions released at this moment won't have effects directly for years, nor will efforts to curb emissions have immediate, positive results. Additionally, although predictions indicate that changes will occur in the near future, it can be difficult to point to direct effects of GCC that are happening *now.*

Scientific evidence is available to show current changes in the climate, but effects can be remote. The Alaskan village of Shishmareff is one of several exceptions to this. It has already experienced major impacts of thawing tundra and retreating glaciers. Images from this area have been useful in demonstrating that communities are already experiencing negative affects of a warming climate (Leiserowitz, 2007). In addition, some of the predicted changes seem so incredible, even with scientific projections behind them, that the population has a hard time accepting them without actually seeing them

start to take place. Examples of such hard-to-believe predictions include significant sea level rise, and significant extinction species.

2. Remoteness of Impacts

Extreme focus on global consequences of GCC can add to the sense that the impacts will be remote and far removed from everyday life. This lack of personalization is problematic in terms of encouraging citizens to take ameliorative action. Historically, proximity and familiarity are important factors that moved people to act on an environmental threat. "Local threats are generally perceived as more salient and of greater urgency than global problems" (Leiserowitz, 2007, p. 53). Although effects will ultimately be local, specific impacts will differ depending on region and topography.

Certain organizations are working to make climate change understanding more personal. Because some understanding of how it can harm local areas is crucial for mobilizing a response, "the IPCC and many other scientific teams are currently working to develop and improve regional and local-scale models of climate change impacts" (Leiserowitz, 2007, p. 54). A risk perception assessment by Bord et al. (2000) claims that in addition to media reports, weather fluctuations are one of the two main influences on public concern. People are more likely to worry about global warming during a drought or in an unusually hot summer (Bord, 2000). So far, however, there is no way to show that individual extreme weather events are directly related to global climate change (Dessai, 2004). Responsible scientists cannot claim for example, that hurricane Katrina was made worse due to warming ocean water. Specific predictions and attributions test the current limits of science. Because those who wish to warn of GCC effects are forced to generalize, the message loses potency.

3. The Tragedy of the Commons

David Orr (1992) calls climate change an even more challenging problem because of its scale. For many other environmental problems, an individual or group of individuals can be held responsible. Climate change, however, is impossible to attribute to one person. The costs are distributed so that it is not always the main producers of pollution that suffer the consequences of their actions. Because one person's actions *are* usually so miniscule on a global scale, it is more difficult to be convinced that drastically changing one's own behavior will make a noticeable difference.

4. Socio-economic Status

Socio-economic status can be a barrier to ERB, no matter how educated one is about the mechanisms involved in GCC. Income determines what car is affordable, where people choose to live, how long an individual works every day, and therefore how much time there is to become educated or active in the community. Affluence can improve ERB by giving one enough leisure and money to buy a hybrid vehicle, or shop for local food. Affluence can work in the opposite way by increasing carbon footprints due to large home size and energy use, or because he or she can afford high gas prices.

Generally, high socio-economic status seems to be related to more environmentally responsible behavior (Tribbia, 2007, p. 237). For this reason, much of the environmental movement has been associated with privileged people who have time to spend lobbying and money to spend on organic food. Environmental problems are also frequently associated with solutions that lower-income people cannot afford. During the spotted owl controversy in the 1980s when environmentalists wanted to stop timber companies from logging in old-growth forests and owl habitats, many low-income

loggers were threatened with losing their jobs. This controversy pitted environmentalists against poor, working-class people. Animosity was summed up in a popular bumper sticker that read: "Are you an environmentalist or do you work for a living?" (White, 1995). In the instance of GCC, many new policies that might lower United States greenhouse gas emissions would most likely also raise taxes and prices for commodities. These higher taxes and prices do generally hit low income people the hardest, meaning that this socio-economic group has more to lose, in the short term at least, and is less likely to vote for GCC legislation. Of course, if GCC is allowed to continue unabated, people in the lower income brackets are also the most vulnerable to its effects.

5. Alarmism and Fear

Rettalack (2006) suggests that portraying global climate change as an inevitable, frightening, apocalyptic scenario makes people - especially children - feel powerless. This is especially important to note given that popular television shows like the "Simpsons," "South Park," and the "Daily Show" have been cited by many younger people as the ways that they have heard about global climate change. The popular Hollywood film *The Day After Tomorrow* plays out a scenario where the earth is plunged into a deep Ice Age in three days, killing millions of people instantly. This information is, of course, for entertainment's sake, but can sometimes be the only way that people hear about the issue. One recent "Simpsons" episode briefly brought up the topic. Marge and her daughter Lisa walk into a museum and come to an exhibit on climate change. A tall glass case encloses a miniature model of the New York City skyline. A disembodied voice instructs, "Press button to see what global warming will do in the next three years." A moment after the button is pushed, water levels rise to the level of the empire state

building roof, and miniature dead bodies float to the top of the water. Lisa's eyes are gigantic while her mother feebly explains, "Three years is a long ways away…" (Groening, 2007).

Some research has been done on how informal educators can avoid this kind of fear. The FrameWorks Institute, an organization that examines how social problems can most effectively be communicated, looked at the reasons that messages about GCC aren't leading to changes in behavior. The Institute "conducted a linguistic analysis of elite discourse on climate change in media coverage as well as of environmental groups' own communications on the issue, followed by one-on-one interviews and focus groups with members of the public and a national poll" (Retallack, 2006, p. 1). It reported that environmental activists were getting the message wrong. Current reporting styles that employ apocalyptic imagery may actually have an immobilizing effect. It found that,

> …the more people are bombarded with words or images of devastating, quasi-Biblical effects of global warming, the more likely they are to tune out and switch instead into 'adaptationist' mode, focusing on protecting themselves and their families, such as by buying large vehicles to secure their safety. (Retallack, 2006, p. 2)

This "adaptationist mode" is further explored by Meijnders et al. (2001), who found that if people are "insufficiently reassured" by recommendations made by GCC activists, they will attempt to find other means of feeling safe, some of which can be inappropriate (p. 756). This can have enormous influences on whether a GCC mitigation policy will have the support of the public. If people perceive that their actions can be effective in lowering a threat, people are motivated to change. However, if "the perceived efficacy is low, increases in the perceived threat will either have no effect or a boomerang effect, leading to decreases in protection motivation" (Meijnders, 2001, p. 757).

Some people who are alarmed at the problem of GCC go way beyond scientific descriptions of the worst-case scenario. “Extreme responses are often apocalyptic, predicting “the end of the world” or the “death of the planet.” These are overreactions to an otherwise very serious problem and may lead some to a sense of resigned fatalism” (Leiserowitz, 2007, p. 60). One is reminded of the ex-smoker’s declaration that if she knew she had only a month to live she would to buy a pack of cigarettes. Many of the most fearful people believe that they might as well live decadently because change is futile.

Many communicators and educators who are drawn to the field because they are passionate about responsible stewardship of the earth stumble into these pitfalls. Because messages are often ignored when the audience doesn’t share similar views on ecological responsibility, education can become very frustrating. It can be tempting to use fear as a motivator. It is not uncommon that this leads to the “impulsive, frustrated, or at least unskilled use of threat and guilt appeals, which are unpredictable at best and counterproductive at worst” (Moser, 2007, p. 71).

Often, messengers of the causes of climate change can point fingers at individuals who are living conspicuously unsustainable lifestyles. This kind of blame often intentionally uses guilt as a motivator for behavior change. Surprisingly, this guilt may lead to the opposite effect. “Research suggests that explicit guilt appeals can indeed evoke such feelings, but do not necessarily persuade or induce behavior change because such individuals just feel resentful and annoyed with overt manipulation (Moser, 2007, p. 71). Guilt triggers defense mechanisms that can obliterate the messages that educators are trying to get across. More information about how fear can be avoided or used to work

with, and not against, education efforts is discussed in Chapter Six.

6. Prior Knowledge and Mental Models

In any learning environment, methods of teaching students about global climate change must be carefully considered. Incomplete or unclear prior knowledge can often cause even the best-planned lessons to fail. In the case of climate change, more research is needed to identify some of the common misperceptions[1]. Students do not come to a science center as blank slates. Extensive surveys and research can help reveal the proper age at which students are ready to learn about certain concepts. Prior knowledge, especially incomplete or erroneous prior knowledge, can stall a student's learning or even make a new concept wholly misunderstood.

> Learning proceeds primarily from prior knowledge, and only secondarily from the presented materials. Prior knowledge can be at odds with the presented material, and consequently, learners will distort presented material. Neglect of prior knowledge can result in the audience learning something opposed to the educator's intentions, no matter how well those intentions are executed in an exhibit, book, or lecture. (Roschelle, 1995)

Bostrom and Lashof (2007) found that generally, when students do not understand concepts they fall back on their "mental models" to explain them. This tendency is best illustrated in the classic study "A private universe" (1988) that asked children and adults to listen to a lecture on astronomy, and then explain basic relationship of the earth, moon, and sun. The study found that rather than accepting new information and incorporating it into their mental models, new information that contradicted erroneous prior learning was either rejected or forcibly rearranged into something new that was equally inaccurate (Schneps and Sadler, 1988). Through calling on vicarious experiences and adopted

[1] A paper on some of the most common misperceptions: Bostrom, Ann., Morgan, M.G., Fishhoff, B., & Read, D. (1994). What Do People Know About Global Climate Change? *Risk Analysis. 14(6),* 959.

beliefs that students might have gained from watching television, science education, etcetera, just about anything can be "explained," including climate change.

This trend has already proven to be problematic. Confusion between the destruction of the stratospheric ozone layer and anthropocentric climate change is very common. This confusion leads people to believe that CFCs are both the main culprit of stratospheric ozone destruction and of climate change. Failure to look further into the distinction between the two problems can predispose them to act in inappropriate ways to ameliorate what they understand as the cause of the problem. In a study by Leiserowitz (2007), one subject interviewed wanted to solve the problem of global warming by "releasing (man-made) ozone into the torn ozone layer" (p. 58). This response indicates that the real problem had been completely separated from an appropriate solution. Effective education is further complicated by the fact that the two issues are actually linked, but not in the way that most of the population believes. CFCs both cause holes in the ozone layer *and* are effective greenhouse gases. Communicators are faced with both the challenge of affirming that there is a link between the two phenomena, and explaining their very great differences (Leiserowitz, 2007).

Similar research has found that while learning about climate change, many people confuse the basic concepts of weather and climate (Bostrom and Lashof, 2007). While the two concepts are extremely related, there are basic spatial and temporal differences between them. Because weather is more accessible and tangible, people often force the characteristics of climate change onto their mental model of weather. While scientists are generally careful to explain this distinction, descriptions and explanations can often be too complicated for a layperson. This misconception often leads people to attribute

unusually warm weather to climate change. Unfortunately, a cold snap in the weather can then challenge their acceptance of the entire phenomenon.

7. Lack of Political Involvement

The common denominator in many successful environmental campaigns is that people have a stake in both the problem and the solution. Most of the successful examples of environmental action have been in response to environmental problems faced in the backyards of ordinary people with no special environmental training. Community members usually take action because they see that they, themselves, are threatened. If people recognize that they will benefit from preventative action and suffer from irresponsible environmental policies and actions of others, they are more likely to act. This means that effective messages must be made personal and local. "By applying these strategies, educators will localize environmental literacy, rendering it relevant and motivating for participants, and ensure the incorporation of critical issues from their lives" (St. Clair, 2003, p. 75).

This trend can be discouraging for environmental educators. Responsible management of the environment means preemptive action rather than waiting until the problem has already occurred. However, elements of this pattern can be useful in communication strategy. Successes in changing behavior have been equally attributed to formal environmental education about local issues and grassroots responses to specific local environmental injustice (St. Clair, 2003). Examples of this include Lois Gibbs' campaign to expose the presence of toxic chemicals in Niagara Falls, New York (Love Canal) and the Indian band Los Coyotes in response to a proposed landfill. In these cases, local people had very real and urgent motivation to change the status quo and improve

environmental conditions. A similar fight against degradation due to climate change will be more difficult given that the causes come from a global community.

The Role of Risk Perception

Although most Americans do believe that climate change is happening and will have destructive effects, they also believe that the effects will not be felt in their communities or in their lifetimes (Yale, 2007). Most do not understand what these effects would even look like. "Few Americans associate global warming with extreme events, such as heat waves, hurricanes, flooding or drought, despite the fact that all are projected to increase in severity due to climate change" (Leiserowitz, 2007, p. 56). Americans know that the effects are not desirable, but without more information about how GCC can affect their lives and the lives of their families, they won't feel that their own well-being is in jeopardy. Climate change "is unlikely to become a high priority national issue until Americans consider themselves personally at risk" (Leiserowitz, 2007, p. 48).

A risk perception study by Bord and Fisher (1999) addresses the assumption that environmental knowledge and an informed awareness of risk would lead to changes in individual's ERB. The study looks directly at how people in the United States perceive the risk of global climate change. Its findings show that risk perception does account for behavioral intentions. Knowledge of causes and effects are key. O'Conner (1999) claims if people understand the causes of climate change, regardless of whether or not they believe it will happen, they are more likely to alter their behavior. However, this pattern is not strong. "Although related, risk perceptions, knowledge, and general environmental beliefs are somewhat independent predictors of behavioral intentions" (ibid). More

studies must be conducted to learn what kind of education actually leads to improved ERB in students and citizens. The wrong kind of education could sabotage efforts to stop or slow climate change by actually decreasing perceptions of risk. “Knowing the causes of a problem and the ameliorative options should promote pro-environmental acts independent of risk perceptions and environmental values. This should be especially the case for `weak signal,’ uncertain environmental threats such as global warming” (O'Connor, 1999, p. 461-462).

Results like these are common in risk perception studies. People are more willing to act if they believe their actions will make a difference. Predictions about what kind of stimulus will lead to ERB are complex. People are neither “nonbelievers” who will take no initiatives and oppose all government efforts, nor are they “believers” who “promise both to make personal efforts and to vote for every government proposal that promises to address climate change” (O'Connor, 1999, p. 461). Although there does not seem to be an indication that the same messages would be viewed as equally dangerous to different individuals, there does seem to be a basic bell-shaped curve describing how different kinds of fear works on risk perception. Low fear and high fear do not elicit strong responses, but mid levels of fear, coupled with applicable and effective suggestions for ameliorative action, seem to work best to increase ERB (Bord et al., 2000).

The Role of Informal Education and Science Centers

Environmental education is further complicated by present public education problems associated with traditional education. These include teacher training, overloaded high school curriculums, and an inadequate ability to instill an environmental

ethic in students. For these reasons, supplemental education is vital. Informal educators like science centers are playing a role in developing a science-literate student population that can effectively understand and address the issues involved in GCC (Rennie, 2003).

Less traditional institutions like science centers and museums are more flexible with what they show students, and have the ability to constantly update themselves with the newest science and information available. According to ASTC environmental educator Craig Fox (1999), "textbooks (and the teachers who rely on them) often impede progress toward science literacy. They emphasize the learning of answers more than the exploration of questions, memory at the expense of critical thought, bits and pieces of information instead of understanding in context." In contrast, science centers don't educate with the intention of testing children at the end of a lesson. They can offer unstructured "opportunities for exploration, critical thinking, and understanding in context" (ibid). They are also in a unique position to compensate for education failures by providing interactive exhibits that take into account different learning styles, and many can accommodate different age groups. These kinds of out-of-classroom settings can best teach students about the complex mechanisms involved in GCC.[2]

It is as important to offer these resources to students as it is to make them available to teachers. Science centers can make sure that teachers are aware of the most up-to-date resources on climate change. They can also provide teachers with effective lesson plans that include hands-on activities that can be done in a classroom with limited resources (See Appendix Two for more resources for science centers in North Carolina).

[2] It is important to note that although science centers are discussed exclusively here, institutions like summer camps, scouts, community garden centers, inner-city outings, and outdoor activity clubs are also examples of great opportunities to offer students time outdoors in an unstructured environment (Louv, 2005).

According to Exploratorium's Rob Semper, "Students and teachers need museums to provide a framework of connectivity and a reality check," something deeper than the mere learning of a specific fact or idea" (Fox, 1999).

Museums cannot expect to teach all aspects of complex issues like climate change, but they can serve to address important concepts. In an analysis of science museum exhibits on weather, education researcher Jeremy Roschelle (1995) suggests that students must first learn basic concepts like weather, the properties of water (i.e. why it expands when warm), and how the greenhouse effect actually operates.

The most useful ability of museums is to serve the role of "raising visitors' awareness of alternative perspectives," (Roschelle, 1995). They can also leave students with the ability to ask "personally relevant questions, tap their current knowledge to enter a new field of inquiry, provide models of constructive learning processes with which visitors can go on learning, and help visitors become aware of books, videos, and other resources that start from what they know already" (Roschelle, 1995). The rest of their information must come from engagement and social interaction with his or her community. The goal of this education is to "instill in learners knowledge about the environment, positive attitudes toward the environment, competency in citizen action skills, and a sense of empowerment" (Athman & Monroe, 2002). This means "communications on climate change should stress the possibility of effective action that can be taken quickly, framed in the context of forward-thinking, efficiency, prudence, and caring" (Patchen, 2006, p. 35).

The Morehead Planetarium Science Center (MPSC) is an example of such an institution. It is currently developing exhibits and programs to contribute to GCC

education. Although only a third of its funding is provided by the government, MPSC already serves thousands of middle school students every year, from hundreds of different schools, usually to teach students about astronomy. With more funding, MPSC plans to create an exhibit about climate change. Maybe at that time high school students taking the earth/environmental science class could visit MPSC to learn about global climate change. Ideally, these exhibits will address climate change explicitly and with the newest science and information available.

Conclusions

Although there is much urgency associated with lowering anthropogenic greenhouse gas emissions, translating this into a sense of public urgency can be difficult. Among other complicating factors discussed in previous chapters, time lags in cause and effects, impacts that many people will never have to experience, issues surrounding the Tragedy of the Commons, socio-economic status, the role of fear surrounding the issue, prior knowledge and political apathy all contribute to a general lack of action. Risk perception is also a complicating factor that can increase or decrease an individual's ERB. Science centers and museums can play a role in compensating for failures in present education.

These challenges will be revisited in Chapter Six, which includes recommendations for how to improve ERB and pubic understanding of GCC. The following chapter will outline a case study that looks at what middle school children in NC know, want to know, and how they've learned about global climate change so far. Chapter Six will draw on both that case study and the preceding literature review on the

state of GCC education in NC and in the United States in general. This chapter will create recommendations and conclusions about what kind of education would be ideal to teach North Carolinians about climate change.

Chapter Five

Global Climate Change Education Survey Report

Summary and Analysis of Findings from MPSC Visitors

The Morehead Planetarium and Science Center (MPSC) in Chapel Hill, NC is interested in developing exhibits and programming to teach the fundamentals of global climate change to its visitors. As part of the preparation for this programming, MPSC invited me to design and conduct a survey to determine the level of understanding that its young visitors have about global climate change. From March through July 2007, 240 students visiting MPSC on school-funded field trips or science camps completed these surveys. Students ranged from third grade through twelfth grade, although the bulk of interviews were of students in the fifth through eighth grade. The surveys were designed to assess visitor knowledge and general attitudes toward GCC. By discerning general attitudes of students, MPSC can better develop an effective strategy of education and basis for their education tools.

The goal of the survey was to give MPSC a better understanding of what students in North Carolina know, want to know, and don't understand about global climate change, as well as to ascertain where and how they learn this information. Schools have difficulty both funding this type of education and training teachers to teach such a complex and dynamic subject. Results of this survey will highlight strengths and weaknesses in students' current knowledge, and guide MPSC in developing an exhibit

and/or programs to better educate students in their target grade range. In the following chapter, survey results will be combined with an analysis of what kind of role science centers could and should play in GCC education. Science centers are uniquely geared toward helping students learn about this topic in a non-threatening way that encourages them to be proactive in the struggle to stop GCC. If MPSC successfully develops the planned exhibits and programming on GCC, survey subjects and others students like them will be able to visit MPSC to learn about global climate change. This case study could also be used to guide other science centers that face the same challenges as they design their education tools.

Subjects

Most students were surveyed while on field trips at MPSC; others were students from science camps or were visiting with family. These three types of students are the main audience for most MPSC exhibits, programs, and events. Survey subjects were originally students in grades 3-8. This range was chosen because it is MPSC's largest audience segment. It quickly became apparent, however, that third and fourth graders had little to no knowledge of global climate change, and the age range was shifted to fifth grade through high school. Even though a total of 21 high school students were interviewed, most of the analysis looks at students in the fifth through eighth grade range. This was also in keeping with the goals of MPSC. Because most visitors are in elementary and middle school, MPSC is most interested in learning about the knowledge and opinions of students in this range so that they might be more accurately targeted in the design and implementation of exhibits and/or programs.

Materials and Methods

The visitor survey used is attached in Appendix One. Contact with the respondent was made through the teacher or chaperone. Although I was the principle investigator, several trained volunteers also conducted interviews with students. After permission to interview was granted, the interviewer chose which student to approach as randomly as possible. The interviewer then personally read a prompt (see Appendix One) asking the student if they would like to participate in a "quick survey" or an "interview". If they agreed, the interviewer would begin by reading the survey aloud. No names were written down. All of the survey was given orally and lasted roughly eight minutes. The term "global warming" was used in all cases to mean "global climate change." This decision was based on evidence that many students are confused by the concept of climate, and more are familiar with the term "global warming" (Rettalack, 2006). If it were clear that the student had not heard of global warming, global climate change, or answered "I don't know" to questions two and three, the surveyor was instructed to gently end the interview and ask the students if he or she had any questions. This was designed to limit stress on students. The result is that many of the later survey questions were not answered. In all cases, I have noted how many questions were not answered, and it can be assumed that these unanswered responses are also "I don't know."

Data Information

Qualitative data was coded by response type. All data was first entered and analyzed by the use of SPSS. Data was then clustered according to school group to control for students in the same class who were more likely to have the same knowledge base. Clustering was done with the use of StataSE. Data collected were confidential. Further publication of this information requires permission from the Institutional Review Board.

Findings

A) Private and public school differences

All qualitative responses were coded by response type in terms of how well a student expressed a basic understanding of the concept of global climate change. "Basic understanding" is classified as identifying in some way that global warming is an anthropogenic global phenomenon that changes the chemistry of our atmosphere and therefore our weather patterns. The student did not have to explain this in entirety, but at least mention a correct cause, effect, or description of GCC. Further responses that were coded as expressing a basic understanding are outlined in the next section.

Most students who were surveyed on visits to MPSC were from public schools. Of the 39 students from private schools in grades five through eight, 36 (92%) had heard of the terms global warming or climate change, 25 (64%) believed it was happening, and 8 (21%) had expressed a basic knowledge of the phenomenon. Of the 161 students from public schools in this grade range, 155 (96%) had heard of the terms, 118 (73%) believed it was happening, and 34 (21%) expressed a basic understanding.

These results show that there is a similar exposure to global warming information of students that attend private and public schools: 92% and 96% have heard the term global warming respectively. The incidence of students who believe global warming is happening is slightly lower among those in private schools (a 9% difference), and a basic understanding of the phenomenon was shown by 21% of students in both groups.

There are not enough respondents in the private school group for the small differences found to be statistically significant, but students from the two kinds of schools did tend to have the same quality of responses. In terms of knowledge base, descriptive statistics show that there is probably not a great difference between a public school students' understanding of the causes and effects of GCC and that of a private school student.

Responses to question five, ("Will you give me an example of a cause of global warming?") were divided into four categories based on how well the response accurately addressed the question. The four responses were Yes, Vague, Ozone, and No. A response was coded as "yes" if respondents expressed that he/she had a basic understanding. Acceptable answers included "smoke from cars/factories," "greenhouse gases," "gases trapping heat," "burning fossil fuels," and anything more specific. Responses were coded as "Vague" if they were not complete enough to determine if the student had a solid grasp of the phenomenon. Vague responses included "pollution," "energy," "cars," or "smoke." Responses were coded as "Ozone" if the student clearly mistook the concept of climate change for the concept of depletion of the stratospheric ozone layer. Confusion with ozone depletion was not initially identified as a projected response, but the great number of respondents who confused these two phenomenon

warranted a separate category. Every other answer (including those who didn't answer and those who said they didn't know) received a "No." Results are summarized in Table One.

Responses to question six, ("Tell me some things you think will happen because of global warming") were also divided into four categories. Coding for these responses was similar to question five. A response was coded as a "Yes" if the subject expressed a basic understanding. Acceptable answers included "sea levels rise," "ice caps melt," "increased flooding/droughts," "more severe storms," and anything more specific. Responses were coded as "Vague" if they were not complete enough to determine if the student had a solid grasp of the phenomenon. Vague responses included "temperature increase" (because it can be easily deduced from the term "global warming"), "animals die," "less trees," or "the environment changes." Responses were coded as "Ozone" if the student clearly mistook the concept of climate change for the concept of depletion of the stratospheric ozone layer. Every other answer received a "No." Results are displayed in Table 2.

A summary of Public/Private school examples of cause and effects are described in Tables 1 and 2 below.

Table 1.

Appropriate Cause Example

			Appropriate cause example?				Total
			Yes	No	Vague	Ozone	Yes
School	Private	Count	8	18	12	1	39
		% within Private School	20.5%	46.2%	30.8%	2.6%	100.0%
	Public	Count	35	75	34	12	156
		% within Public School	22.4%	48.1%	21.8%	7.7%	100.0%
Total		Count	43	93	46	13	195
		% within Public/Private School	22.1%	47.7%	23.6%	6.7%	100.0%

Table 2.

Appropriate Effect Example

			Appropriate effect example?				
			Yes	No	Vague	Ozone	Total
School	Private	Count	12	15	11	1	39
		% within Private School	30.8%	38.5%	28.2%	2.6%	100.0%
	Public	Count	45	58	46	7	156
		% within Public School	28.8%	37.2%	29.5%	4.5%	100.0%
Total		Count	57	73	57	8	195
		% within Public/Private School	29.2%	37.4%	29.2%	4.1%	100.0%

B) Grade differences in knowledge of causes and effects.

Among the target grade range of fifth though eighth grades, I interviewed 31 fifth graders, 117 sixth graders, 47 seventh graders, and only five eighth graders. The much higher number of sixth graders is due to the fact that the sixth grade curriculum covers astronomy, and a field trip to the planetarium is a common supplement for this material. Knowledge of causes and effects are outlined below according to grade level.

Cause

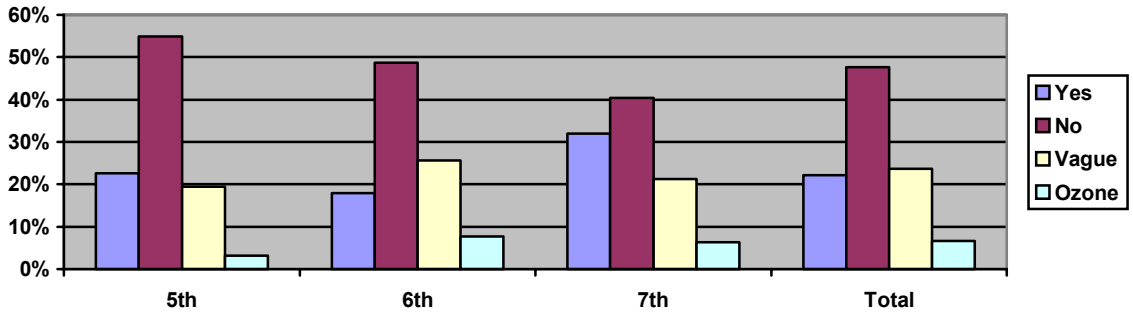
Question five asks, "Will you give me an example of a cause of global warming?" Among the fifth graders, 23% of students (7 of 31) knew a basic cause, 20% (6 of 31) answered vaguely, 3% (one of 31) confused the cause with ozone depletion, and 55% (17 of 31) could not give an example of a cause. That means that 55% of fifth graders could not give even a vague cause of climate change. See Figure 1.

Among the sixth graders, the percent of correct and incorrect answers both dropped. 18% of students (21 of 117) could name a basic cause, 26% (30) answered vaguely, 8% (9) confused the cause with ozone depletion, and 49% (57) could not give an example of a cause. These responses show that 56% could not give a vague answer to the question of the causes of climate change. See Figure 1.

Seventh graders tended to give more knowledgeable responses. 32% of students (15 of 47 students) knew a basic cause, 21% (10) answered vaguely, 6.4% (3) confused the cause with ozone depletion, and 40% (19) could not give an example of a cause. See Figure 1.

Among the five eighth graders surveyed, none expressed a basic understanding, two answered vaguely, one mixed up ozone and climate change, and two did not provide causes for climate change. Because of this small sample size, eighth graders were not included in Figure 1.

Figure 1.



Responses are further summarized in Table 3.

Table 3.

Appropriate Example of Cause by Grade

			Appropriate cause example?				
			Yes	No	Vague	No - ozone	Total
Grade	5	Count	7	17	6	1	31
		% within Grade	22.6%	54.8%	19.4%	3.2%	100.0%
	6	Count	21	57	30	9	117
		% within Grade	17.9%	48.7%	25.6%	7.7%	100.0%
	7	Count	15	19	10	3	47
		% within Grade	31.9%	40.4%	21.3%	6.4%	100.0%
Total		Count	43	93	46	13	195
		% within Grade	22.1%	47.7%	23.6%	6.7%	100.0%

Effect

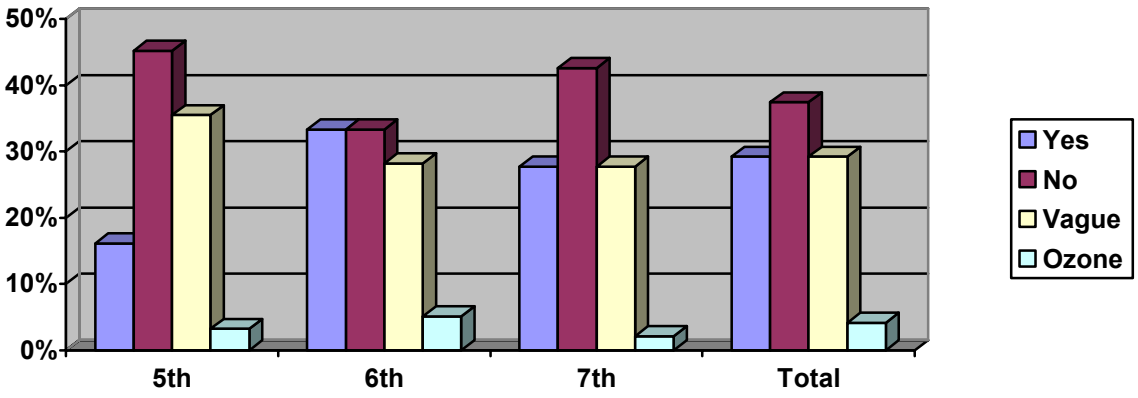
Question number six asks, "Tell me some things that you think will happen because of global warming." Among the fifth graders, 16% of students (5 of 31) knew a basic effect, 11% (11) answered vaguely, 3% (1) confused the effect with the effects of ozone depletion, and 45% (14) could not give an example of an effect. See Figure 2.

In this case, responses from the sixth graders were more accurate than the fifth graders. 33% of students (39 of 117) knew a basic effect, 28% (33) answered vaguely, 5% (6) confused the effect with ozone depletion, and 33% (39) could not give an example of an effect. See Figure 2.

Among the seventh graders, 30% of students (14 of 47) knew a basic effect, 23% (11) answered vaguely, 2% (1) confused the effect with ozone depletion, and 45% (21) could not give an example of an effect. See Figure 2.

Among the eighth graders, one student expressed a basic understanding, three gave vague answers, and one didn't know of any effects. Again, because of the small sample size, eighth graders were not included in the table or graph below.

Figure 2. **Knowledge of Effects**



Responses are further summarized in Table 4:

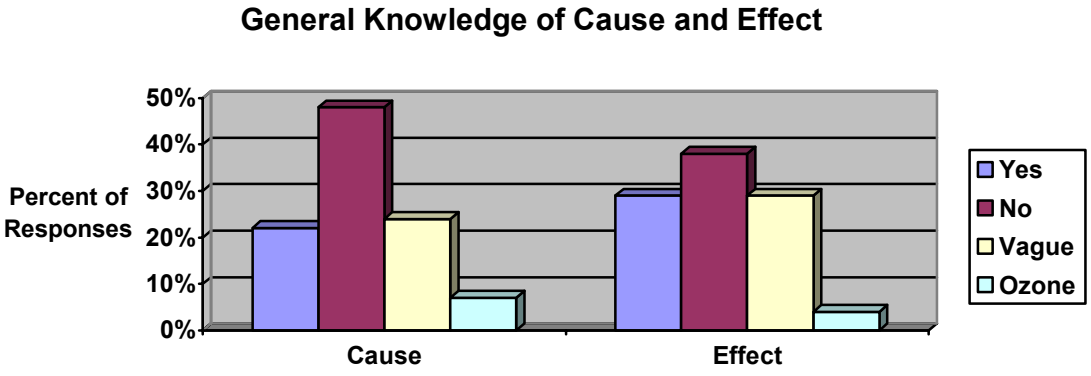
Table 4.

Appropriate Example of Effect by Grade

			Appropriate effect example?				
			Yes	No	Vague	No - ozone	Total
Grade	5	Count	5	14	11	1	31
		% within Grade	16%	45%	36%	3%	100%
	6	Count	39	39	33	6	117
		% within Grade	33%	33%	28%	5%	100%
	7	Count	13	20	13	1	47
		% within Grade	28%	43%	28%	2%	100%
Total		Count	57	73	57	8	195
		% within Grade	29%	37%	29%	4%	100%

These results are not statistically significant but are useful for describing general trends. To summarize among the entire target grade range, 22% of respondents could give satisfactory causes, 24% of these answers were vague, 7% confused their responses with ozone, and 48% were unable to give an adequate response. For question number six, 29% could give satisfactory effects, 29% gave vague effects, 4% were confused with ozone, and 38% could not provide a response. Figure 3 shows a comparison of overall knowledge of causes against overall knowledge of effects.

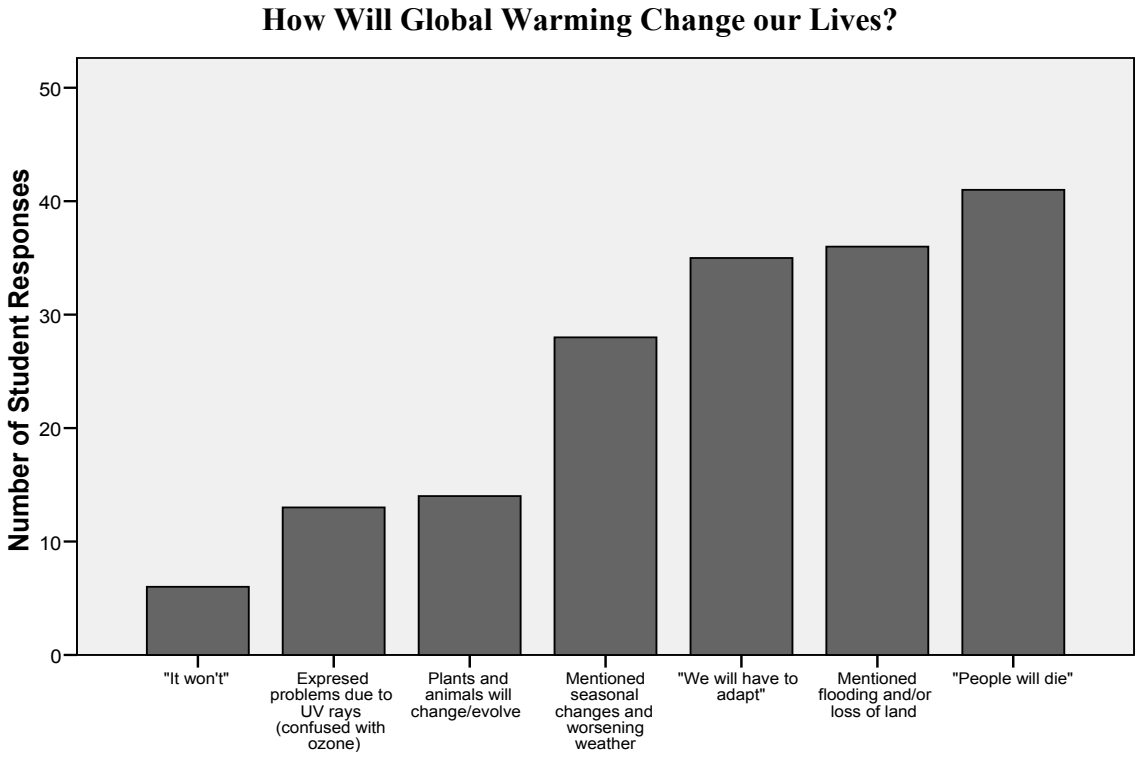
Figure 3.



C) How Will Global Warming Change our Lives?

Question number 7 asks, "How will global warming change our lives?" Responses were coded by type of response. Graph 4 illustrates the variety of responses. "No Answer," "Vague" "Everything," and "Don't Know" were excluded from this bar graph so as to more clearly compare the opinions of students who expressed a conviction about how global warming would affect humans. Responses from seven students who specifically mentioned that we'd need to find more fuel were grouped in the "we will have to adapt" category (27 responses total). See Figure 4.

Figure 4.



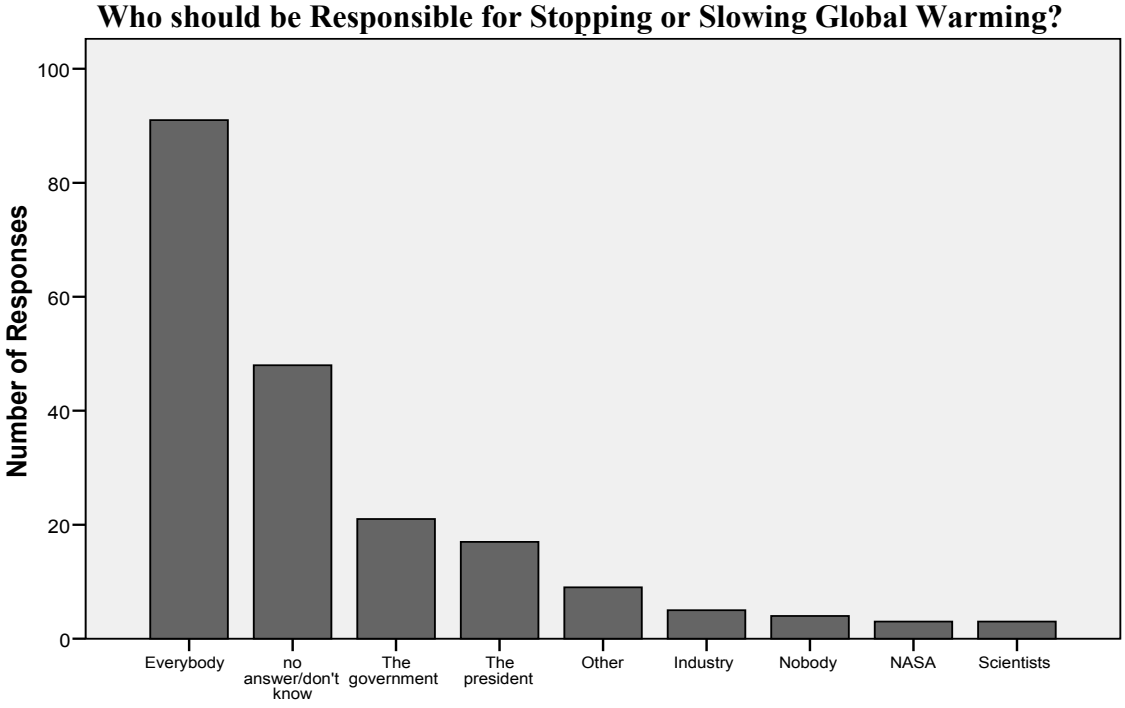
D) Who is generally held responsible?

Question 11 asks, "Who should be responsible for stopping or slowing global warming." Questions were coded into seven categories, and since some students named

more than one person or group, overall percentages will be greater than 100%. Here are the basic types of answers and how they were coded: 48% said "everyone[1]," 29% either didn't know or did not answer because they were not asked (in order to avoid stress on young students, those who clearly did not know about global warming did not finish the survey - see limitations section). 19% said governments were responsible (81% of those respondents said the president or presidents in general were particularly responsible), 5% said scientists (five out of these nine respondents named NASA in particular. This high number could be attributed to the fact that students had just attended a class at MPSC that discussed NASA briefly), 3% said industry, 3% said nobody was responsible because it's not happening or because it is natural, and 2% named other people as culpable[2]. See Figure 5.

[1] This response could be complex. Because interviewers were not instructed to probe further into this "everybody" response, there is no way to determine whether this response was sincere and self-inclusive or whether students used this term dismissively.
[2] These 4 respondents listed "farmers and people who have to work with the earth," "young people in this generation," "teachers," and "the people who live in areas that global warming will affect."

Figure 5.



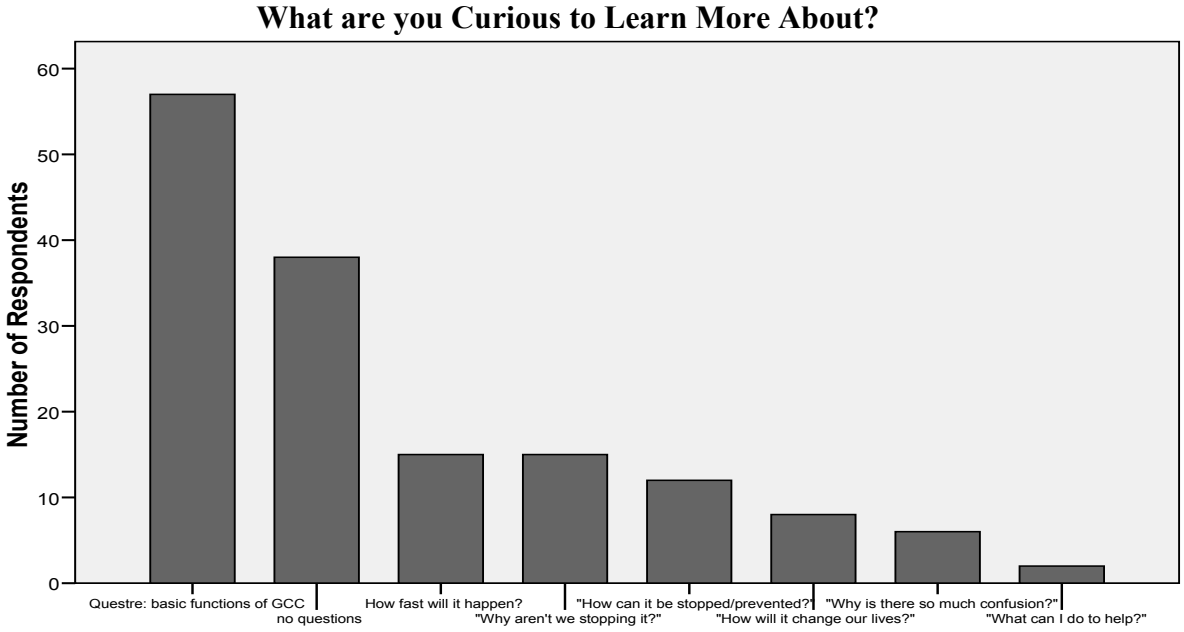
E) Questions

Question 12 asks, "What are you curious to know more about global warming?" If a further prompt was needed, the surveyor asked, "What is confusing to you?" Answers ranged from non-sequiturs like "What's it like to land on a star?" (fifth grader), to more common questions regarding the basic causes and effects of global warming. Questions were coded into eight categories, and since some students asked more than one question, percentages will be greater than 100%. Here are the basic types of responses and how they were coded: 27% did not answer - "no answer." 21% said that there was nothing more they wanted to know - "no question[3]." 29% asked a question about basic causes and effects of global warming - "basic function." 4% wanted to know how it would affect their lives personally. 8% asked questions regarding when global warming would

[3] Responses that included "no question" could also imply that students were simply unwilling to ask a question, not that he/she felt completely clear on the subject.

"happen" and/or how long it would last. 8% asked more abstract questions about why more action isn't being taken. 7% asked questions about what individuals and/or countries can do to slow/stop/prevent global warming from happening. 3% were questioning either the science behind it or the mixed messages they had been exposed to. "Why is there confusion?" was the basic theme here. Answers are listed in Figure 6.

Figure 6.

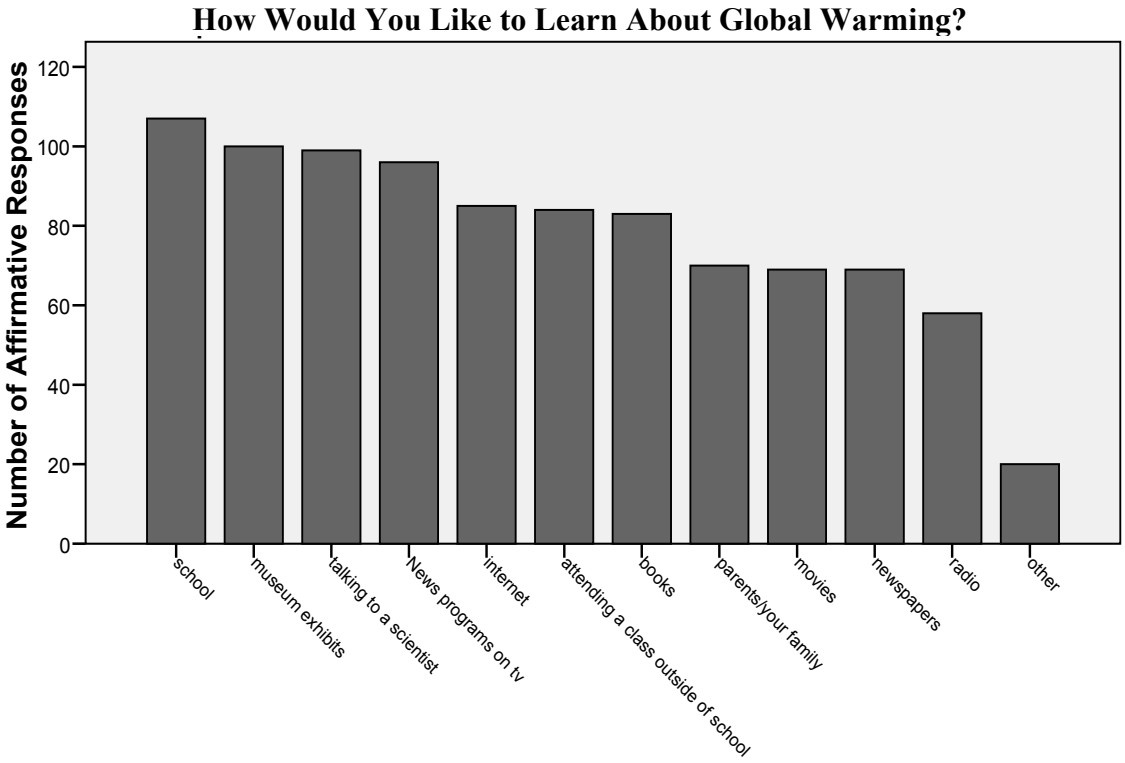


F) How most students would like to learn about GCC

Question 13 asks, "How would you like to learn about global warming?" Students could reply with a "yes," or "no" to specific items read aloud to them. If they had an extra suggestion, they were prompted for this at the end of the list. Of the students who answered (145 total), responses were as follows: 68% said "news programs on television," 60% said "internet," 41% said "radio," 59% said "books," 69% said "talking to a scientist," 49% said "parents or family," 77% said "school," 59% said "attending a

class outside school like a camp, church, synagogue, or library," 49% said "movies," 50% said "newspapers," and 71% said "museum exhibits." Results are shown in Figure 7.

Figure 7.



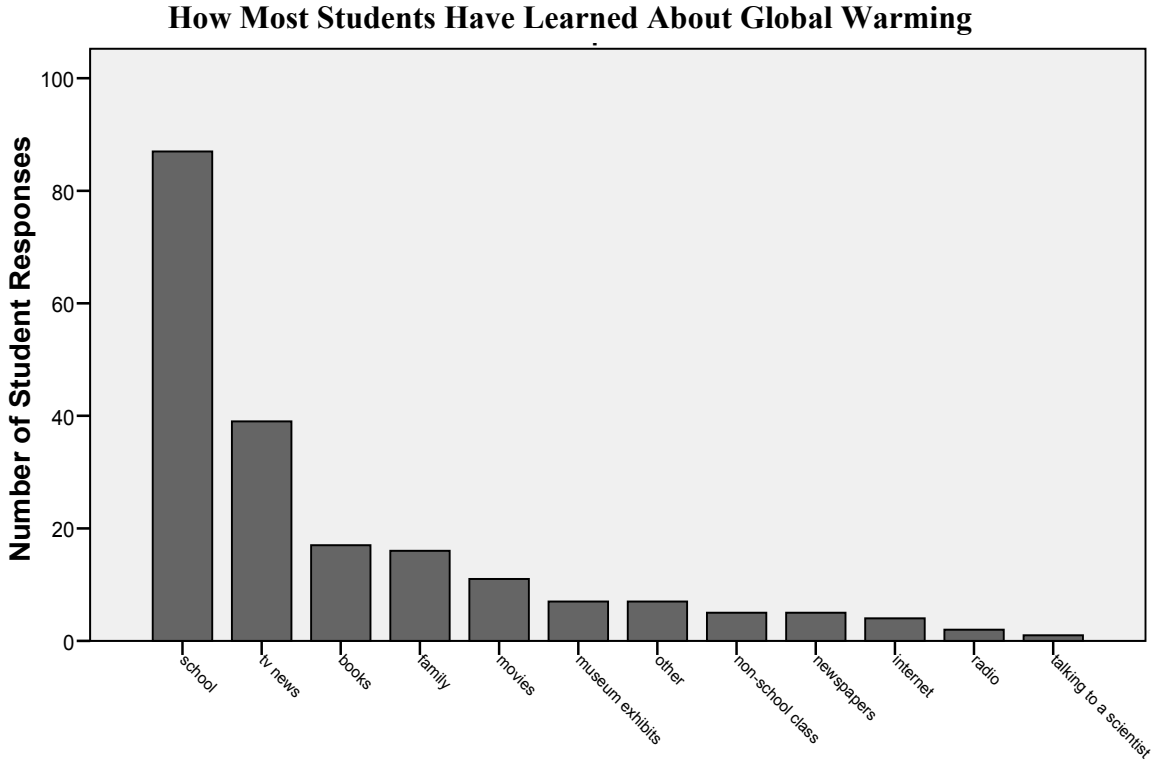
An additional element of this question was whether students could think of other ways they'd like to learn about global warming. 20 students made suggestions. Several students mentioned that they would like to see visual images of the effects of global warming. Many others suggested turning it into entertainment and putting it in television shows and movies "where characters have to deal with it"[4].

[4] Other suggestions listed by students: would like to learn by "seeing it ourselves" like Hurricane Katrina, comics, speakers and a discussion, people's shirts, protestors, by becoming a scientist, TV shows like South Park and the Simpsons, hobos with signs, ads in magazines, virtual effects, presidential speech, science movies, fly a big banner, clubs for kids, billboards, ads, rap songs, activities showing what will happen, "planet earth" videos on global warming, action movies where someone has to fight it or someone dies because of it, government describing it for us, people on the streets.

G) **How most students have learned about GCC in the past**

Question 14 asks, "Of those things I just listed, which would you say has given you the most information on global warming so far?" Again, students frequently gave more than one answer so the totals listed are greater than 100%. The same list from the precious question was read aloud to them again. Of the students who answered (145 total), responses were as follows: 28% said "news programs on television." 5% said "internet" (many students complained that the internet wasn't reliable enough and a lot of the information on it was "bad"). 2% said "radio" (many students commented that "kids don't listen to the radio"). 11% said "books," 1% (one student) said "talking to a scientist," 13% said "parents or family," 60% said "school," 5% said "attending a class outside school like a camp, church, synagogue, or library," 10% said "movies," 2% said "newspapers," and 3% said "museum exhibits" (Note: this number could be falsely high, since several seemed to think they had learned it at the planetarium. No camps, exhibits, or programs at the MPSC teach explicitly about climate change; students may have confused climate change with what they had learned about the stars and planet Earth, or in a class called "Extreme Weather"). See Figure 8.

Figure 8.



Commonly, students said that they had heard about global warming through television shows ("South Park," "The Simpsons," and "The Daily Show" were listed). At least six students said that they had seen information on the Discovery Channel. Six students mentioned that they had watched the film The Day After Tomorrow, and 12 had seen Al Gore's documentary An Inconvenient Truth.

Question 16 asks explicitly if students had seen information about global warming at a museum. This question was asked for MPSC's own clarification. 13% of 5th, 22% of 6th, 19% of 7th, and 40% of 8th had learned about global warming in a museum. Of the target grade range, 21% had visited a museum and learned about the topic. Again, this number could be artificially high because many students could not express an

understanding of GCC; therefore, a recollection of learning about it is problematic. For example, several students responded to this yes or no question with "I think so…"

H) If students do not believe GCC is happening, are they less likely to know basic[5] information about it?

Question four asks "Do you think it's really happening?" 41 students (21%) responded with "No" or "maybe." Of these, 12% could give a cause, 26% answered vaguely, 2% confused the issue with ozone, and 56% gave incorrect answers or said they didn't know.

In order to understand if there is a correlation between knowledge and belief that it was happening, these results were compared with general knowledge of GCC. Of the 16 students who said "no," none could give causes of global warming, although half could give an accurate effect. Results are displayed in Tables 5 and 6.

Of the 151 students who did indicate that they believed it was happening (eight students total in the grade range had never heard the term), 26% gave accurate answers as to how it was caused, and 26% could at least give vague causes. 8% confused the topic with ozone, and 43% did not give even a vague cause, or said they didn't know. Although it is not statistically significant[6], trends show that most subjects who said it wasn't happening had poorer knowledge of its purported causes and effects than subjects who believed it was happening.

[5] See Public/Private school section for a review of how "basic" is defined.
[6] In all cases, the term "statistically significant" means that p-values are less than 0.05%.

Table 5.

Beliefs about Global Warming and Knowledge of its Causes

			Appropriate cause example?				
			Yes	No	Vague	No - ozone	Total
Is it really happening?	Yes	Count	37	56	35	12	140
		% within	26.4%	40.0%	25.0%	8.6%	100.0%
	No	Count	0	11	5	0	16
		% within	.0%	68.8%	31.3%	0%	100.0%
	Maybe	Count	6	11	6	0	23
		% within	26.1%	47.8%	26.1%	0%	100.0%
Total		Count	43	78	46	12	179
		% within	24.0%	43.6%	25.7%	6.7%	100.0%

Table 6.

Beliefs about Global Warming and Knowledge of its Effects

			Appropriate effect example?				
			Yes	No	Vague	No - ozone	Total
Is it really happening?	Yes	Count	49	39	47	5	140
		% within	35.0%	27.9%	33.6%	3.6%	100.0%
	No	Count	2	9	3	2	16
		% within	12.5%	56.3%	18.8%	12.5%	100.0%
	Maybe	Count	6	9	7	1	23
		% within	26.1%	39.1%	30.4%	4.3%	100.0%
Total		Count	57	57	57	8	179
		% within	31.8%	31.8%	31.8%	4.5%	100.0%

I) Role of school

Question 15 asks, "Have you learned about any of this [global warming] in school? Of the 149 who answered, only 29 said they had not. Because 54 students did not answer this question, it can be safely assumed that they did not remember whether or not they learned it in school. Therefore, of the total number of students who took the survey (200), 65% said that they remembered covering the topic in school in some way.

However, if students did indicate that they learned about global warming in school, they were asked to describe how they were taught about it. 15% of these students couldn't recall how they learned about it, or expressed that it was only mentioned as a passing comment. The lack of memory of how they learned about GCC leads one to believe that many students may have heard a teacher mention global warming or global

climate change, but were not presented with a lesson on the topic. This reflects upon the quality of learning and retention of the material. Although Table 8 shows that most students say they learned about GCC in school, further questions (shown in Table 7) reveal that the actual number of students who retained this information is much smaller. A total of 57% of students in this grade range could not remember how they had learned about GCC, if at all. See Tables 7 and 8.

Looking at the results of this question according to grade level is problematic. Because many students are drawing from knowledge they learned in several previous grade levels, it is difficult to determine what they learned in each grade. Still, it is useful to look at what they can recall from education and at what grade level their knowledge seems the best. 61% of fifth graders recalled learning it in school, 68% of sixth graders, and 62% of seventh graders. These results could be misleading, since not all students had finished their grade level at the time of the survey. Based on these results, the peak of understanding seems to come at grade six. See Table 8.

Of the students who did remember learning about global warming in school (119 total), none indicated that they had learned about global warming outside of science class. If they did learn about GCC in school, the ways they remember learning were coded into six categories and are outlined in Table 8. Those who were not more specific than "science class" were coded as "SC general." Some respondents were able to be more specific. These responses included "activities," "readings," "visuals," and "discussion/lecture." Students who said that they did learn about global warming in school but expressed that they either don't remember how they learned, or that it wasn't

more than a passing comment were coded as "don't remember." Totals are greater than 100% because many students mentioned more than one type of activity.

The two tables show different results in terms of the total number of students who say they learned about global warming in school. Table 7 shows that 57% of all students interviewed either didn't learn, didn't remember, expressed that GCC was only mentioned, or didn't answer the question because they weren't informed enough about GCC to be asked to finish the survey. In table 8, only 35% of respondents self-reported that they hadn't learned about the topic in school.

Table 7.

Sources of Information About Global Warming in School

	5th grade	6th grade	7th grade	Total of all grades
Science class (SC) general	6%	9%	17%	10%
SC activities	3%	9%	9%	8%
SC readings	16%	14%	17%	15%
SC visuals (including movies)	6%	20%	4%	14%
SC discussion/lecture	6%	14%	19%	14%
Didn't learn/Don't remember/expressed that GCC was only mentioned/No answer	61%	34%	34%	**57%**

Frequencies of students who say they learned about GCC in school are listed in Table 8.

Table 8.

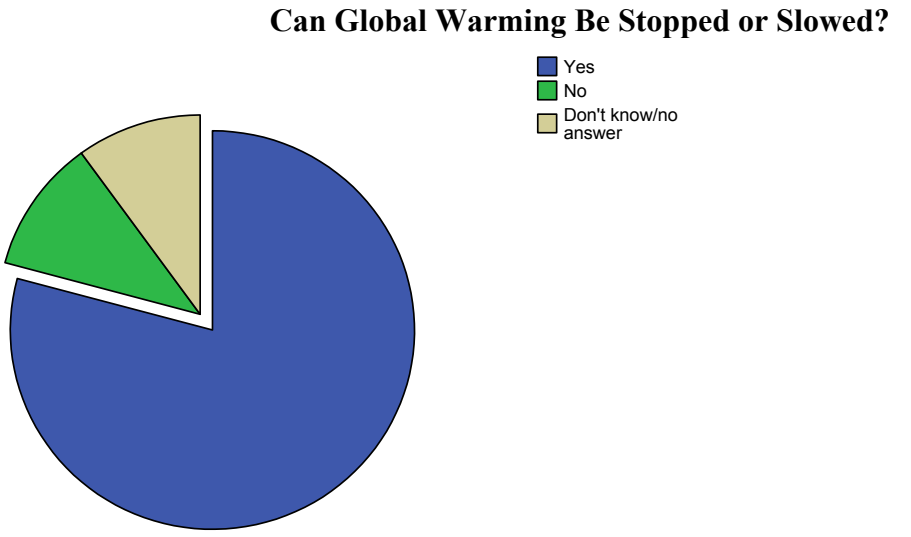
Did you Learn About Global Warming in School?

			Did you learn about GW in school?		
			Yes	No/No Answer	Total
Grade	5	Count	19	12	31
		% within Grade	61%	39%	100%
	6	Count	79	38	117
		% within Grade	68%	33%	100%
	7	Count	29	18	47
		% within Grade	62%	38%	100%
Total		Count	127	68	195
		% within Grade	65%	**35%**	100%

J) Attitudes about our ability to stop global warming

Question ten asks, "Do you think we can stop or slow global warming?" If yes, "How?" If no, "Why not?" Generally, students were hopeful that global warming could be stopped or slowed, although most students did indicate that they believed it could only be slowed (unfortunately, the distinction between "stopping" and "slowing" was not a direct question and exact data could not be quantified). 63% replied with "Yes," 9% said "No," and the other 28% either did not know what they thought, or did not answer because they were not familiar with what climate change at all. Fifth graders were generally optimistic: 71% said yes, none replied that it couldn't be stopped or slowed, and 29% didn't answer. 62% of 6th graders said "yes," 11% said "no," and 27% didn't answer. The seventh graders responded in roughly the same proportion, with 63% saying "yes," 11% saying "no," they didn't think global warming could be stopped or slowed, and 26% didn't answer. A pie chart showing general responses among 5th, 6th, and 7th graders combined is shown in Figure 9.

Figure 9.



41% of the students who said it could be stopped or slowed gave reasonable responses to "How?" They either gave an answer indicating that they knew greenhouse gases produced by cars and factories, burning gasoline, and/or indicated that some behavior change that required less energy was needed.

Limitations

The much higher numbers of sixth grade visitors to MPSC made comparisons between grade levels problematic. Because there was a limited amount of surveyors to help, and a limited amount of time to contact students, a full, nuanced picture of the knowledge and opinions of the fifth to eighth grade age group was not possible.

Students who were present for the study were perhaps more privileged than other students whose schools or parents did not have the resources to send them to MPSC. Because only three respondents were visiting with parents without a school group, the data from this group probably did not significantly skew results. The differences between MPSC audience and those who don't go on field trips at MPSC are unknown.

In order to avoid stress on young students, those who clearly did not know about global warming were not asked to finish the survey. This resulted in several "no answer" responses.

Although surveyors chose students to interview as randomly as possible, many students refrained from being interviewed for this study. Students who chose not to participate may have done so because they felt unable to answer the questions, or may have simply been uncomfortable talking to a stranger. It is difficult to estimate how this may have skewed the survey population.

Analysis

Common Misconceptions

Various questions on the survey lent themselves to discovering some common misconceptions that students had about global warming. Misconception examples from subject responses include[7]:

Belief that global warming will lead to an Ice Age. Five students believed that an Ice Age was coming. This idea could possibly be taken from the popular film "The Day After Tomorrow," which portrays a massive and abrupt shift in climate due to global warming.

Confusion between the issue of global warming and that of ozone depletion. Many agreed that, "UV rays are going to hurt us" and that "we are going to have to wear a lot more sunscreen" and/or protective clothing. Other responses included, "Machines set off fumes that break the layer" (sixth grade). Global warming is caused by, "Hairspray, industries, and trucks" (tenth grade). "Gas puts holes in the ozone. These holes cause global warming" (fifth grade). (The differences between gasoline and gases seem to be a point of confusion here). Confusion with stratospheric ozone depletion was common and was cited in the findings from questions five through eight. This misconception is often cited and common even among high school students and the rest of the public (Rettalack, 2006).

Confusion about the specific effects of global climate change in different regions. In question number nine, 43 out of 147 students (29%) said that yes, "the effects of global warming will be the same all over the world." Students tended to mean that the world

[7] All conceptions listed have been identified in a minimum of 5 student responses.

would get warmer in all places evenly, although because this question was not asked formally, there is no way to quantify this belief.

Failure to distinguish between the natural greenhouse effect and the man-made enhancement of that effect. This may be related to language use; the term "greenhouse effect" is in some contexts used to denote a man-made increase in greenhouse gases, and to refer to the natural greenhouse effect. "Global warming is caused by the greenhouse effect" (sixth grade). At least five students named "the sun" as the culprit for global warming.

Notion that visible pollution or environmental degradation causes global climate change, rather than CO2 and other invisible gases. "Smoke and littering cause global warming" (sixth grade). "Oil spills," "trash," and "littering" were also commonly listed as factors that led to global warming.

Specific examples of visible effects of global warming seemed to affect the younger students more. While high school students seemed to be more able to list the broader effects of climate change like drought, floods, severe storms, etc, younger students who were able to name an effect of global climate change seemed to be apt to call attention to the smaller and more tangible effects. Some examples of this response are: "No snow when we were supposed to" (seventh grade). "Penguins will die on polar ice caps" (sixth grade). "It will rot fruit faster and animals will die" (fifth grade). "We'll drown under water" (sixth grade).

Quality of Knowledge

It is interesting to note that the knowledge of effect seems to be highest among sixth graders, but is not necessarily being translated into knowledge of what is causing global climate change (see Figures 1 and 2). The lower rates of knowledge of global climate change among seventh graders could be due to the fact that the curriculum has been changing each school year, or because the students who learned it in sixth grade are not retaining knowledge of climate change a year later.

Fear

A common sentiment among students was fear regarding global warming. While unfortunately there was not a question on the survey that explicitly explored fear, many students expressed fear within their answers. Keywords here were "death," "die," "cancer," "scary," and "end of the world" responses. Mention of fear often surfaced when students responded to question number two, "What comes to your mind when you hear the words 'global warming'?" One sixth grader responded with, "The earth is rotten." A fifth grader said that global warming will "erase the life." Several students from a private parochial school mentioned the apocalypse. Also note that when students were asked how global warming would change their lives (Figure 4), a large percentage said that, "people will die." A total of sixty student respondents expressed some sort of fear within their answer without even being asked. There is clearly much anxiety surrounding this topic. As discussed in Chapter Four, fear can keep a student from becoming engaged and willing to learn about how to stop or slow global climate change. The goal for GCC

education would ideally be to replace these fears with a sense of empowerment and responsibility. This will be further discussed in the Recommendations section.

Conclusions

Although findings for this survey were unsurprising, they illustrate a general lack of understanding among students in schools that come to MPSC. Students don't seem to be consistently learning about it in school or from any other source. Subjects seem to show no major differences in understanding, whether they are students at a public or private school. For students in all grades levels knowledge of causes is generally better than their knowledge of effects, although in Tables 1 and 2 it can be seen that the knowledge of effects was higher than causes. This difference is not statistically significant in either case. When asked, respondents chose a wide range of ways they'd like to learn about the topic. School was the most common answer, and radio was the least. 60 percent of students who responded to the question, "Where have you learned the most about global warming so far?", answered with "school." From this question, sixth graders were the most likely to say that they had learned about it in school. This suggests that at least some information is presented to this age group.

In terms of opinions about GCC, most students believe it is happening. Students who didn't believe it was happening usually had a poorer knowledge of the issue. A large majority believes that global warming will change their lives, although to different degrees. Students were generally vague in their responses to the question of "who is responsible for stopping or slowing global warming?" Most students answered, "everybody," and only a few were more specific. Most of the questions that subjects

asked concerned the basic functions of global warming (e.g., "How does it work?"). 21 percent had no questions, indicating that they felt they had enough information about GCC already. Subjects were also generally optimistic about our ability to stop or slow GCC, with over three quarters of respondents saying that it could be done.

This case study can be useful for assessing general levels of knowledge for this demographic, as well as for identifying common misperceptions that must be corrected for effective education to move forward. More studies about how students and adults in North Carolina perceive the threat of climate change in their lives are needed. This field is still so new and changes so are occurring so quickly that it is vital for educators to make sure that messages are interpreted correctly. The role of fear in information processing and environmentally sustainable behavior is another major question. More work must be done to determine the best ways to approach this age group. Fear was a recurring topic in many survey responses, and must be carefully addressed. More information on this can be found in Chapter Four, and recommendations for how to effectively deal with fear are discussed in the next chapter, which also outlines other ways for educators, activists, and communicators to approach the complexities of GCC education.

Chapter Six

Recommendations

The challenge for environmental communicators is to teach about global climate change in ways that allow students to become environmentally literate and encourages them to lead more sustainable lives. Because both children and adults are frequently either not receiving basic information about GCC or the information is fragmented or inaccurate, this is a critical moment for other environmental educators to step in. Museums and science centers are ideal for this kind of public education. Although most research about GCC communication looks at adult experiences and perceptions, it offers lessons that educators can use as they design exhibits and programming to teach about climate change. Adult education and learning patterns can inform education methods that target school-age children. Proper education can ensure that the next generation of adults is better equipped to respond to global climate change than the present adult generation. Some recommendations follow to guide environmental educators as they address this important and complex subject.

Prior Knowledge

Because of prior experiences and knowledge, children sometimes translate discourses designed to explain complex subjects like climate change in surprising ways. Children use their own schemata to make sense of their experiences. “Students quickly acquire many different kinds of knowledge, but only slowly acquire the ability to

coordinate and integrate these different sources of understanding" (Roschelle, 1995). Amalgamating opposing experiences can sometimes mean children leave more confused than when they arrived (see chapter four for more information on how prior knowledge can negatively affect the goals of science lessons).

There are many ways that prior knowledge can be exploited, however. If exhibit designers are careful and have accurate information on common misconceptions among a certain age group, these misconceptions can be corrected, or at least compensated for. Educators should not attempt to destroy prior knowledge and replace it with their own. Instead, they should work on identifying a learner's misconceptions and refining knowledge from that point (Roschelle, 1995). The previous MPSC survey described in the previous chapter was able to highlight several common points of confusion, and other researchers have been able to highlight other ways that GCC education causes children to become confused (see "Common Misconceptions" in chapter five, and "Prior Knowledge and Mental Models" in chapter four). These misunderstandings must be confronted in order for new knowledge to become integrated.

Basic Knowledge

In many ways, basic knowledge is more important than expressing an interest in helping to curb global climate change. Even if a person claims that he or she is concerned about the environment or about pollution, it does not mean that a person will be motivated to support corrective measures. Simply knowing about air pollution is not sufficient to explain the complexities of GCC. People must be able to correctly identify basic mechanisms in order to understand what they can do to live a sustainable lifestyle.

"A basic understanding of cause and probable effects is necessary, with all the uncertainty and complexity included" (Bord et al, 2000, p. 216).

Based on the results of the MPSC survey and information from other studies that have been conducted about GCC education, I conclude that sixth grade is probably the best time to approach North Carolina students with information about it in a science center format. Both developmentally and in light of what they have already learned in school, this is probably the youngest age that children are prepared to learn about GCC. In fifth grade, students are expected to learn about weather and climate. Because this unit can be taught at different times during the school year, focusing programming only on this grade could be problematic. If students have not yet learned about these topics, they will not be as prepared to learn about climate change. By sixth grade, they should have covered basic information about what makes weather, the role of the atmosphere in regulating climate, and earth science skills that could prepare them to begin to understand the relatively complex mechanisms involved in global climate change.[1] Because it is still somewhat new material to sixth graders, however, there is still an opportunity to contribute to a students' understanding of the issue, rather than confront it after prior knowledge has possibly confused the issue.

Sixth grade students represent a convenient group for GCC education in most school systems because this is already a common grade for students to visit science centers like the Morehead Planetarium and Science Center and learn about the solar system. At this institution, students generally stay for a half-day. Exhibits or

[1] The standard course of study for these grades is outlined on the following web pages: www.ncpublicschools.org/curriculum/science/scos/2004/17grade5, and www.ncpublicschools.org/curriculum/science/scos/2004/19grade6.

programming for climate change would simply lengthen the field trip. Global effects of humans could fit in nicely with information about atmospheres and chemical make-ups of different planets. Financially, this could also be the best time for schools to enroll their students in GCC education programs because they are already paying the fees for buses and field trip chaperones (resources that could be helpful in designing such a project can be found in Appendix Two).

Fear

Fear is presents a complex communication issue. Because GCC has such devastating possible consequences, it is common for people to worry about them in an unproductive manner. Most previous research on fear has been focused on how fear affects adults; more research is needed on how it can specifically affect children's learning. Educators should be extremely sensitive to the risk of inducing fear in these students, and be sure that exhibits and programming are age appropriate.

Many science centers do provide education tools for adults as well as children. Because children tend be afraid of different things than adults, these two groups respond to messages of global climate change in different ways. However, in either demographic, appealing to people's emotions in order to teach about GCC can create unpredictable results. As Moser (2007) notes, "emotions can be powerful motivators as well as de-motivators of action. Thus, playing with emotional appeals to create urgency is like playing with fire" (p. 69). As discussed in chapter four, people respond best when positive emotions were summoned in the education process. Respondents from focus groups say that they would be most likely to change their environmental behavior

because it was important to them to be a good person (Moser, 2007). Messages that appealed to peoples' logic and responsibility have also created positive results. It is important to keep in mind that education on climate change is not unlike many other efforts – people want an opportunity to "derive gratification from exhibiting their strengths, talents, and virtues, and use these skills and strengths to belong to and serve a larger purpose (Moser, 2007, pp. 74-75). People want to think beyond their own needs and believe that they are contributing to something larger than themselves. Because of this need for validation and a sense of agency, small, individual solutions to GCC must be coupled with suggestions of ways to participate in a community-wide manner. Otherwise, messages are met with skepticism.

> Depicting frightening, global scale catastrophe and focusing entirely on something as seemingly uncontrollable as the weather frames the issue as completely outside human control. Following these kinds of newscasts with suggestions like using a more efficient light bulb seems laughable. It "evokes a disconnect that undermines credibility and encourages people to think that action is meaningless … [A] typical global warming news story – outlining the scientific proof, stressing the severe consequences of inaction and urging immediate steps – was causing people to think that preventative action was futile. (Retallack, 2006, p. 2)

Skepticism based on perceived futility of individual actions is a major concern for GCC communicators. From a child's perspective, small changes can make sense. However, it is more difficult to make an adult – who is more aware of the scale of global problems – believe that he or she is able to contribute to GCC abatement by merely changing a light bulb. Communication aimed at adults must include tangible ways to immediately vote differently, consume differently, and influence others to do the same. Messages aimed at children should provide tangible ways that they can use less energy,

like encouraging them to turn off lights when they're not in use, or playing outside rather than playing video games.

It can be difficult to constantly hear depressing news about the effects of global warming. When relentlessly faced with such a threat, it can be hard to stay optimistic about our ability to change our lifestyles, overcome technological and economic challenges, and "appropriately address the economic, social, ethical concerns in the process… The problem is too big, too complicated, too overwhelming – it's hopeless" (Moser, 2007, p. 65). This kind of hopelessness can be caused by some of the most well meaning GCC educators. For some activists who would like to convey a sense of urgency, it is tempting to present the matter in as alarming a way as possible. However, bombarding the public with emotionally charged pleas to "change their destructive ways" can be counterproductive if communicators don't take into account how these messages will be received. This strategy can summon up excessive feelings of guilt. Moser (2007) suggests that there are only certain moments when a threatening tone can lead to a constructive response. These are when people

> …feel personally vulnerable to the risk; have useful and very specific information about possible precautionary actions; positively appraise their own ability (self efficacy) to carry out the action; feel the suggested action will effectively solve the problem (response efficacy); believe the cost associated with taking precautionary action is low or acceptable; view the reward for *not* taking the action as unappealing; and tend to consciously and carefully process threat information. (Moser, 2007, p. 70)

Although shame should be avoided, it is possible to use an emotional appeal to explain why people should act to prevent climate change to an audience and still hold their attention. Occasionally a feeling of guilt about a negative environmental impact can lead to a positive behavior change. Meijnders et al. (2007) claims that if the message

conveys a thorough explanation of why one should be afraid, and if a recommendation is simultaneously provided that can plausibly alleviate the cause of the fear, fear can be a positive motivator. This recommendation must be an explicit suggestion of reasonable alternative behavior that will "also reinforce (or at least not undermine) one's self-identity" (Moser, 2007, p. 71). Solutions must support the idea of how that person would like to be viewed and how he/she would like to view him/herself. Children are likely to want to see themselves as good at sports, bike riding, or other outdoor activities, so these activities should be encouraged. An example of strategies for adults would be to provide ideas for how a business person can make their business be seen as more environmentally aware, or to suggest a bike route to a person who sees him or herself as ecologically conscious and physically fit.

Uncertain Science

Climate is notoriously difficult to predict far into the future. GCC communicators must therefore talk openly about uncertainties that remain in climate science. This is also the moment that educators must be clear in distinguishing *climate* on the one hand, and *weather* on the other. Although definite, long-term predictions are too complex to make, educators can frame what science does know in the sense of the "likelihood and severity of potential impacts, and narrate scenarios that describe possible local and regional futures" (Leiserowitz, 2007, p. 56). It is important to explain why this uncertainty exists, but also to explain that uncertainty is not ignorance and that it can be quantified in such a way as to bound the range of possibilities and to assign likelihoods. Audiences must understand that although there is a limit to what technology can reasonably predict, it is

also a powerful source of information for policies and the public[2].

Despite the fact that the nature of science is to sometimes create more questions than it answers, it can be used to help people imagine how GCC might change their lives, and generally "highlight the connections between climate change, human health, and extreme weather events" (Leiserowitz, 2007, p. 56). It is essential to focus on what scientists *do* know. Images are useful tools here. Showing retreating glaciers and thawing tundra visually reminds audiences that although there is uncertainty about details, very real changes are happening now. The general public – not just sixth graders – needs to learn about the complex nature of science and the reasons for lack of predictability. People will inevitably hear of debates going on in the scientific community about the effects of GCC. Without education, the mere presence of these debates can shake the foundation of their understanding of climate change, and result in skepticism about the entire issue.

Personal Interaction

It takes more than just education for people to become committed to changing their behavior. A study of environmental activists in Kentucky, USA, and Norway "found that education was mentioned as a source of commitment by only 38 percent of overall respondents. Experience of natural areas (77%), family (64%), and participation in environmental or outdoors organizations (55%) were mentioned significantly more frequently" (cited in St. Clair**,** 2003, p. 73). This should be a major focus of education of young people.

[2] Reasons for the lack of predictability and more discussion on the role of science in GCC education are included in Chapter Three in the section entitled "Scientists".

Although education of adults is important, education at an early age before consumption habits and behavior are hardwired is best. Personal interactions with nature have been shown to be the biggest contributor to positive environmental behavior later in life (Falk and Dierking, 2002; Klotz-Chamberlain, 2005). Studies have shown that the people who tend to worry and care about the environment are those who spent unstructured time outdoors as a child, and whose parents' attitudes and behaviors promoted environmental awareness (Falk and Dierking, 2002). In general, children will become more concerned with protecting the environment if they spend a day at a river rather than a week in the classroom. These kinds of experiences tend to impress upon children that their daily life is affected by and affects the natural spaces around them like the atmosphere, soil, and water bodies.

Play as a young child is a vital part of education. Play outside or in designed learning environments such as science centers can significantly augment environmental education with a personal interaction. "Play is pleasurable, spontaneous, and voluntary" (Rennie, 2003, p. 113). Field trips and science museums are a perfect opportunity for play as long as exhibits and programming are targeted toward young children. "To the extent that the museum promotes uninhibited, free, playful, childlike behavior, it is an ideal environment for the study of motivation, curiosity, choice, interest, and expectations. (Rennie, 2003, p. 114). This kind of play often translates into later self-identification as an environmentalist. Environmental historian Bill Cronon describes his experience this way:

> …when I think of the times I myself have come closest to experiencing what I might call the sacred in nature, I often find myself remembering wild places much closer to home. I think, for instance, of a small pond near my house where water bubbles up from limestone springs to feed a series of pools that rarely freeze in

> winter and so play home to waterfowl that stay here for the protective warmth even on the coldest of winter days, gliding silently through streaming mists as the snow falls… (Cronon, 1995, p. 13)

Because personal interactions with nature are so important yet so difficult to arrange in a classroom setting, informal educators should use their diversity of resources to fill the gaps that formal education cannot.

Conclusions

Communicators must be thoughtful about how information about environmental problems is received. More work is needed to determine what this education would look like in practice, but basic guidelines exist. A base of environmental literacy can support further education about the public's role in environmental resource use. When literacy is based on what people experience locally and daily, people are more inclined to link their efforts with a more global scale concerns. Education must then aim to instill "positive attitudes toward the environment, competency in citizen action skills, and a sense of empowerment" (Athman & Monroe, 2002). In this way, science centers have the opportunity to promote environmental literacy that could later mean, "developing and participating in the social practices likely to change the way our societies think about and act upon ecological issues" (St. Clair, 2003, p. 77). Messages about climate change should both be informative and "stress the possibility of effective action that can be taken quickly, framed in the context of forward-thinking, efficiency, prudence, and caring" (Patchen, 2006, p. 35). Environmental communication is not complete without this kind of behavior and motivation shift.

Designers of educational resources like museum exhibits, class curricula, and science camps should be aware of the role of prior knowledge, and also make sure their lessons complement what students are getting from other aspects of their education. Designers must also take into account that learning depends on social interaction. Students must have the opportunity to explore new information and have conversations about their roles in environmental problem solving. "Only part of specialized knowledge can exist explicitly as information; the rest must come from engagement in the practice of discourse of the community" (Roschelle, 1995). Practiced in this way, learning is more likely to be memorable and therefore effective in the long-term. More studies must be conducted to learn where educators should go from here, to decipher what kinds of education we can reasonably expect to lead to more informed citizens and sustainable behavior.

Global Climate Change is essentially a social issue that challenges people to work together to overcome substantial challenges. The question is how the public will cope with the potential of calamitous climate change, and how, if at all, it will work to prevent this from occurring. Building simple knowledge and concern about the issue will not be the "cure" for global climate change. Among the many steps that must be taken to curb this problem is the education of citizens and future citizens who will feel empowered to change their behaviors, support policies that can ameliorate the causes associated with GCC, and who know that it is their action or inaction that creates the problem. Children must be given the tools to become environmentally literate, and impressed by the importance of slowing and possibly stopping this trend. Environmental communicators have been given the challenging yet critical task of creating a learning environment that

promotes future environmentally sustainable lifestyles among our youngest citizens and the generations after them.

Appendix 1:

MPSC Global Climate Change Survey

In-Person Introduction:

Hello, my name is Carly Apple. I'm working with the Planetarium to take a survey of its visitors to help us decide how to create an exhibit and programs on global warming. Would you mind answering a few questions about global warming to help us with the exhibit? Your answers will help us understand what visitors already know about global warming, as well as what kind of information they would like to learn and how they'd like to learn about it. You do not have to answer these questions if you don't want to. You can also stop answering at any time. If you decide to stop, no one will be angry or upset with you. Your parents and teachers won't even read about what you have said. You will not receive any money or gifts for being in this research study. It should take about ten minutes. There are no right or wrong answers. I'm not even going to write your name down; I just want to get your thoughts. Would you like to participate?

Date:
Time began:
Grade Level:
School:

I. Introduction

1. Do you live in Chapel Hill, or are you visiting from somewhere else?
   Chapel Hill resident____ Visiting _____ From_____

2. Have you ever heard of the terms "climate change" or "global warming"?
   Yes _____ No _____

** If no, use visual prompt like glaciers melting with dates, etc. Record if prompts are needed. If the student has never heard of the terms, record and skip to thank you.*

II. Knowledge

3. What comes to your mind when you hear the words "global warming"?
   _____
   _____

**if needed, use prompts like "Can you tell me a little more about that?"*

4. Do you think it is really happening? Yes___ No___ Maybe ___

5. Will you give me an example of a cause of global warming?
   _____
   _____

6. *(If not already addressed in question 3:)* Tell me some things that you think will happen because of global warming.

_____
_____

7. How will global warming change our lives?

_____
_____

8. Can you think of any positive things about global warming?
   Yes___ No___
   (*if yes*) What are they?

_____
_____

9. Will the effects of global warming be the same all over the world?
   Yes ___ No ___

**Use a map for this question. If the visitor doesn't provide an immediate answer, prompt them with, "Will NC be affected the same way Canada is affected?"*

10. Do you think we can stop or slow global warming?
    Yes ___ No___
    (If yes) How?
    (If no) Why not?

_____
_____

11. Who should be responsible for stopping or slowing global warming?

_____
_____

III. Role of education

12. What are you curious to know more about global warming?

_____
_____

*** If prompt is needed, ask, "Is there something that is confusing to you about global warming?"*

13. How would you like to learn about it? *(read aloud and circle all that apply)*
    a. News programs on television
    b. Internet
    c. Radio
    d. Books
    e. Talking to a scientist
    f. Parents/your family

g. School
h. Attending a class outside of school, like a camp, church, synagogue, library
i. Movies
j. Newspapers
k. Museum exhibits
l. Something else you can think of? _____

14. Of those things I just listed, which would you say has given you the most information on global warming so far? _____

15. a. *If the visitor didn't list "school", ask directly:* Have you learned about any of this in school? *(anything related to global warming)*
Yes___ No___

b. *If yes, or if the visitor listed "school":* How did they teach you about it in school? Did you have any activities in class to help you learn about it? Tell me about them.

_____
_____

16. Have you ever seen information at a museum on global warming?
Yes ___ No ___

IV. Summary

17. If you were going to explain global warming to someone else, is there anything you would say differently, or add to what you have said?

_____
_____

Thank you so much for helping with this survey. This kind of information is very useful to us and will hopefully help other museums around the state when they set up exhibits and programs on global warming. You're welcome to ask any questions about the study, or stop back later and ask about how the project is going.

Record questions here: _____

* If time is limited, make sure questions from original study goals have been asked:
How would you like to learn about global warming?
What would you like to learn more about?
Where have you learned most of your information so far?

Appendix 2:

North Carolina Environmental Education Resource Menu

This list briefly describes resources that could help the North Carolina science centers design and support programs and/or exhibits on climate change.

This "menu" includes:

Databases
Educational Media
Exhibit and Programming Examples
Science Center Resources
Teaching Supplements
Teaching Enrichment Opportunities

I. DATABASES

Environmental Defense
www.environmentaldefense.org/pagwoulde.cfm?tagID=818

Environmental Defense has created an extensive database for information on climate change. It focuses on what our government is doing now about global warming and therefore would be useful for older students and as a resource for more research. It has several links to learn about what is happening in terms of policy in different parts of the country, a great list of "Climate Change Movers and Shakers," but also a great link on "global warming myths" that debunk a lot of common misunderstandings about climate change including questions about scientific consensus, what carbon restrictions would do to the economy, etc. This organization has also provided a useful paper about global climate change effects in the Southeast. This could be helpful in making the programs and exhibits more geared toward how GCC would affect familiar ecosystems in this area.

Environment North Carolina
www.environmentnorthcarolina.org/issues/energy/global-warming

This website is unique in that it covers the sources of greenhouse gases in North Carolina in particular. It also has links to more information about legislation in North Carolina regarding climate change. It could be a good resource for information specifically about this state.

ERIC database – Education Resources Information Center
www.eric.ed.gov/ERICWebPortal/Home.portal

This is a user-friendly digital library of education literature.

NC LIVE
www.nclive.org

This website is a great reference tool for supplemental learning. Already it is being used in the classroom in NC, but it could also be used by as a discussion tool. Climate change/global warming information here centers on current events and general scientific reports.

NSF - Science and Engineering Indicators
www.nsf.gov/statistics/seind06/toc.htm

This is a great resource for public opinion polls either done by the NSF or supported by them. It is a good way to get a current picture of the state of science and technology education, as well as a source of information on other public opinions/knowledge levels on similar topics.

Scholastic
www2.scholastic.com/browse/teach.jsp

This website was mentioned by students at MPSC and is a good resource tool for teachers. Its search engine could be a great resource in terms of finding current news that engages students' attention. It has a link to lesson plans, "strategies" (to motivate or ways to organize information), and books and authors.

II. EDUCATIONAL MEDIA

Climate Connections Video
www.npr.org/news/specials/climate/video/

This link contains a video sponsored by NPR and National Geographic. It is part four in a five-part series of shorts about global warming. Its cartoon format and humor make it great for middle school age students.

Green Planet Films
www.greenplanetfilms.org/?gclid=COHLkumrr40CFQb9gAodim29ug

Green Planet Films is a non-profit distributor of nature and environmental DVDs. Could be a useful resource if the science center is interested in showing films.

Follow the link to "Going Green – Every Home an Eco-home." Targeted at middle school students, this film shows simple and inexpensive ways to become more "earth-friendly." In addition to learning about composting, conserving water, and household hazardous waste, the students learn about solar water heaters and solar panels. It includes a discussion guide (24 minutes. Rent for $7.99 or purchase for $27.95).

This film does not yet directly address GCC, but there is a link here to EarthDance International Environmental Film Festival that looks very interesting. Science Centers can rent a compilation of short films from around the world that celebrate peoples' relationship to their natural world. Many of them talk about new ways to live sustainably without sacrificing much of their lifestyle (Rent for $7.99 or purchase for $20.00).
http://greenplanetfilms.org/product_info.php?cPath=98&products_id=356

LEAD – Linked Environments for Atmospheric Discovery
https://portal.leadproject.org/gridsphere/gridsphere

"LEAD makes meteorological data, forecast models, and analysis and visualization tools available to anyone who wants to interactively explore the weather as it evolves." This resource provides links to many web-based weather education programs. This could help make an interactive exhibit possible. It also has features organized into how it can best be used to help different users. There is a link for weather features geared toward researchers, educators, students, or visitors. Another links helps visitors explore local weather patterns on a colorful, interactive webpage. The content is visually stimulating and easy to use. It is frequently updated and seems very current.

III. EXHIBIT and PROGRAMMING EXAMPLES

Marian Koshland Science Museum
www.koshlandsciencemuseum.org/exhibitgcc/index.jsp

The Koshland Science Museum is so far at the forefront of GCC exhibitions in the country. It has a great interactive exhibit site that lets visitors explore different aspects of the phenomenon. Links include information on the greenhouse effect, the carbon cycle, causes of change, past change, predicted change, impacts of change, and responses to change. This seems to be a thorough coverage of some of the most frequently asked questions and difficult concepts to teach. Extensive teaching tools and activities are also available here. This is a great model for other science centers and science museums.

San Francisco Exploratorium
www.exploratorium.edu/climate/global-effects/index.html

The San Francisco Exploratorium website has computer simulated models on the effects of global warming on the planet in terms of Risk of Malaria Transmission, Annual Mean Precipitation as Simulated by a Global Climate Model and Observed Values, Sample Forecasts of Future Temperature Change, Average Annual Global Number of People Flooded under Three Emissions Scenarios, and Change in Annual Sea Surface Temperature under Four Emissions Scenarios. The information was funded by the NSF. The models look great – they could be a good resource and contact for this kind of information for the exhibit.

The Exploratorium website also has links to the International Research Institute for Climate Prediction (IRI), and the Hadley Centre for Climate Prediction and Research. Both links could be useful, but the IRI is especially user-friendly "This research institute, based at Columbia University, offers a data library, information on prediction, forecasting, and modeling, and the Climate Information Digest, a monthly summary of recent climate events all over the world."

The Exploratorium has a great question and answer section on their site. Already someone had posted the question "How likely is it that CC could have significant global effects over the next hundred years?" This kind of question and answer option (ex. "Ask the experts" dropbox) could be incorporated into an exhibit. Answers to visitors could be answered by scientists (or any "expert") and posted online.

The Exploratorium's Global Climate Change site received a Pirelli INTERNETional Award for environmental publishing. The site also won an Honorable mention in the database category at the MUSE Awards at the American Association of Museums conference.

Science North Enterprises' Climate Change Show
http://sciencenorth.ca/enterprises/climate/index.html

This show is a 3000 square foot traveling exhibit that has been very popular in the science centers it has visited. Although it is unclear how expensive it would be to have on loan, it seems to be a very hands-on and engaging exhibit. Visitors learn about the climate history of North America, learn about the impacts of climate change, and test their knowledge of how climate change affects their daily lives. The "Climate Change Object Theater" is an interesting take on how to let visitors experience climate change. It can recreate environmental effects including a thunderstorm that visitors experience inside the theater. CGI sheep explain the causes and effects with humor, and the show is targeted at all ages. Although this option may be prohibitively expensive for some

science centers, the exhibit is interesting and could provide some inspiration for something that could be done at another science center.

Trucking with Climate Change
www.globallink.org.uk/exhibitions/cc/

Global Link, a Development Education Center based in the UK, has created the exhibit "Trucking with Climate Change." It is a fully interactive, multimedia exhibition built into an 8.7m by 5.7m trailer. Designed for young people and adults, it provides the opportunity to think about several different questions relating to climate change including: What is Climate Change? What is happening now? What will happen in the future? How can we change it?

Each participant walks through four different rooms, each explaining about climate change, the problems, the facts, and ways that together we can change it. Throughout the trailer the interactions are through film footage, climate change models, computer games and other interactions explaining the processes and problems. This could be a great model – it not only educates but highlights what people can do to help, but also aims to inspire them to act now.

IV. SCIENCE CENTER RESOURCES and ASSISTANCE

ASTC – Association of Science-Technology Centers
www.astc.org/resource/index.htm

This website has excellent resources for science centers. This is also the place to find information on IGLO – International Action on Global Warming. It uses the International Polar Year (March 2007-March 2009) to raise worldwide public awareness about global warming and the ways the polar regions influence Earth's climate, ecosystems, and human society.

ASTC is committed to providing science centers with resources that cost as little money as possible. They provide education resources on their website that include articles and other resources that suggest new ways to effectively teach visitors in science centers. This page also has a link to exhibits to find summaries of different inexpensive exhibit ideas that have been developed in science centers in different parts of the world.

Campus Consortium for Environmental Excellence
www.c2e2.org/climatechange.htm

This organization focuses on helping individuals, environmental activists, museums, and science centers to get "the message of climate change to resonate with the average person or student." It focuses on symbols, signals, and stories that will effectively reach a wide range of audiences. Although the site is focused on college-level activities and programs, CCEEdoes a good job of keeping current and providing information about how to aim education tools toward different ages as well. CCEE is careful to outline what kinds of messages people should take home with them, and how to make the messages stick.

This website includes "Communicating Climate Change" streaming video and "Climate Change Ed: Tuning the Message." These could be great supplements to a climate change exhibit.

Children's Environmental Health Initiative website
www.nicholas.duke.edu/cehi/

If science centers are interested in helping to create a database of information, the CEHI website could be a good model of a clearinghouse for scientific/policy-based information and education.

CRed – The Community Carbon Reduction Project at UNC-Chapel Hill
www.ie.unc.edu/content/research/cred/index.html

The CRed program is an initiative of the Institute for the Environment at UNC Chapel Hill. It has made the reduction of carbon dioxide emissions on the campus, the local community, the State of North Carolina, and the United States a core aspect of its education, research, and outreach activities. Because this education campaign is public, it could be a great collaborator for future work and as a general resource of information.

DESTINY Bus
www.moreheadplanetarium.org/index.cfm?fuseaction=page&filename=destiny.html

The Destiny Bus is a traveling exhibit that is capable of visiting schools and other science centers in North Carolina. The unique atmosphere of the DESTINY bus would work well with GCC education. A segment could be designed to fit well with what students are already learning in school.

Earth Day Network
www.earthday.net

The Earth Day Network would be a good program become involved with. Although not a direct resource for programming or exhibits, its links could be useful for educators and science center staff to stay current in what is going on in terms of action campaigns. For example, it has links to "Earth Day 2007 Review," "Pledge to Switch your Bulb," "Offset your Event's Carbon Emissions," and "Climate Change Solutions Campaign." Any of these campaigns would be an activity for science center visitors.

ERP – Environmental Resource Program at UNC
www.ie.unc.edu/erp/index.cfm

The ERP provides technical assistance to community groups, offer K-12 teacher professional development, conducts policy research for non-profits and government agencies, and sponsors undergraduate environmental internships. All of these services could be helpful in GCC program development.

A "Climate Change and Public Health" flier (attached) was produced by this group and its format and general information could be useful as a way to organize information for middle school aged students.

Family Science
www.familyscience.org

The Family Science website aims to give parents and children ideas for inexpensive hands-on activities. It has links to order books and contact information so that science centers can host a Family Science event

Grassroots Science Museums Collaborative
www.grassroots-science.org/NCISC.html

This collaborative is useful as a resource for staying up to date with other science centers that may also be working with global climate change programming.

International Polar Year
www.ipy.org

The International Polar Year is a large scientific program that focuses on the Arctic and Antarctic from March 2007 to March 2009. Because the poles have been considered such "canaries in the coal mine," institutions like ASTC and science centers have taken this opportunity to look into how to combine this program with global climate change education. IPY is partnered with other educators that could become important collaborative opportunities for other science centers. There could be great opportunities

coming up to either participate in events or get ideas from what other science centers are doing in response to this program.

Science Centers can download:

- posters: www.ipy.org/index.php?ipy/detail/ipy_posters/
- fun group experiments and activities: www.ipy.org/index.php?/ipy/detail/ipy_2007_2008_school_launch_event/
- opportunities for teachers and students: www.ipy.org/index.php?/ipy/detail/teacher_opportunities/
- ideas for the classroom that could also be used in climate change programming and summer camps: www.ipy.org/index.php?/ipy/author/juanita/

Northeast Science Center Collaborative
www.sciencecentercollaborative.org

The goal of this collaborative is to bring the latest information and ideas about teaching about climate change to science centers. Ideas for activities and ways of conveying information are being refined and collected all the time. The website includes links to "Climate 101" aimed at middle school students, as well as links to other websites that could be helpful to science center planning.

The link to the "climate change backpack" (www.sciencecentercollaborative.org/backpack.php) is probably one of the most useful links. It has ideas for small projects that families or school groups can work on by themselves or with staff members, and require very little money or materials. NSCC also offers Backpack Trainings as well as a Presenters Guide. This backpack has been tested in many different science centers and could fit well into any exhibit on GCC.

North American Association for Environmental Education
www.naaee.org/

NAAEE is a network of professionals, students, and volunteers who work in the field of environmental education. It provides guidance on how to effectively teach people how to think in new ways about the environment. The NAAEE holds conferences so that people facing similar challenges can meet and discuss EE methods.

Useful links on this site include the "Higher Education Directory," information about how teachers can become EE certified, and professional development opportunities for EE professionals. It also has a running list of current publications geared towards those teaching in this field. This could be a good source for literature and guidance for science center programs.

North Carolina Association of Environmental Education Centers
www.eenorthcarolina.org/eecenters/ncaeec/ncaeec.htm

The ACAEEC works to foster cooperation among Environmental Education Centers in North Carolina. Its purpose is to combine all of the state's environmental education resources into one website. Stated objectives include establishing regular and multiple lines of communication among EE centers, creating and maintaining a central clearinghouse of information about EE centers, building public awareness and support for EE centers, and developing and promoting standards for these centers. This group could provide a great opportunity for collaboration and for keeping an eye on what other science centers are doing. It also has a link to a working list of grants that could be useful for funding a project.

Science Centre Impact Project
www.aspacnet.org/apec/

The Asia-Pacific Economic Corporation (APEC) has developed the SCI project for museums and science centers in all APEC economies, but it can be useful to MPSC in many ways. It has links to global climate change news happening in parts of the world, especially parts of the world where GCC news is relatively overlooked. The site posts research here on "big picture" overviews of how GCC will affect people personally, culturally, economically, and legally. Importantly, this section also contains materials on research methods for science centers and museums.

The SCIP site has a link to "case studies" and examples of best practice from science centers and museums in that region. This could be a good link to keep an eye on to find more ideas and discover what environmental education organizations are doing in other parts of the world. Included on this page is a topic called "How's your world?" It outlines a program where students can send in pictures, a written pieces, or videos about how climate change is affecting them and their communities. Submissions are posted on a website (www.aspacnet.org/apec/case_studies/challenging_topics.html)
and later users can click on a location and view a perspective on climate change in that area. This could be a great activity for middle school students to contribute to after they have learned a bit about the processes involved.

Another important feature of the SCIP site is that there is a way for science centers to get involved here as well and advertise what it will be doing with climate change education. Science centers who have been through attempts at creating this kind of programming can post their successes and the problems that they have run into while creating educational material (www.aspacnet.org/apec/get_involved.html). This is another website to keep an eye on.

Science Under the Seas
www.scienceunderthesea.org/

This website describes a collaboration of UNC professors (John Bruno and Chris Martens), Philippe Cousteau, and high school and middle school students. They study in a lab called "Aquarius," located 50 feet under the sea, 3.5 miles off the coast of Key Largo. Their experiments focus on the interactions between sponges, nutrients, and coral reef health. They will chronicle their studies of reef ecology and chemistry in a short documentary film, and will also facilitate the live internet link-up with the North Carolina students. In addition, LEARN NC, North Carolina teachers, and the Morehead Planetarium and Science Center are working with the group to integrate North Carolina curriculum goals into the project activities. This innovative collaboration will bring current scientific research into North Carolina classrooms, cultivating interest in science among students and educating the public about the global crisis of coral reef decline. Because coral reef decline is related so closely to global warming, this could be a great visual to aid and/or interactive tool to teach about some of the effects of GCC on sea chemistry and sea life.

V. TEACHING SUPPLEMENTS

AAAS – American Association for the Advancement of Science Project 2061.
www.project2061.org/publications/2061Connections/2007/2007-02b.htm?tx

The AAAS website offers "Project 2061," a guide for teaching global climate change. It is a 32-page guide aimed at grade school students. It focuses on the skills and ideas that are required in order to understand the science of climate change, as well as the reasons that the science is sometimes difficult to interpret. It also outlines the benefits and drawbacks of technology.

This resource is particularly effective in that it recognizes that science literacy is central in helping students grow up to be citizens that understand the nuances of climate change impacts on our world. The included link to "Communicating and Learning about Global Climate Change: An Abbreviated Guide for Teaching Climate Change" provides science educators with an overview of Project 2061's recommendations for what all students should learn about climate change and its environmental and societal implications.

Earth Eco International
www.eartheco.org

"Dedicated to inspire a sense of stewardship for our planet and to help others create an environmentally sustainable future."

EarthEco International works to educate adults and children about the environment and promote sustainability. It collaborates with organizations to spread environmental awareness through a variety of media. Some of the organizations include Animal Planet, American University Center for Filmmaking, UNC-Chapel Hill, Morehead Planetarium, Smithsonian Natural History Museum, and the National Council for Science and the Environment. This website is especially useful for highlighting how individuals can make a difference by eating healthy foods, carpooling, bike riding, and advocating a philosophy of reduce, reuse, and recycle.

EPA Governmental Education Sites
www.epa.gov/climatechange/

The EPA climate change website includes links to Basic Information, Science, Greenhouse Gas Emissions, Health and Environmental Effects, US Climate Policy, and What You Can Do.

EPA's age-targeted websites:

- The EPA student website educates children currently in middle school (Grades 5-8): www.epa.gov/students/.
- The EPA highschool sites predictably focuses on educating grades 9-12: www.epa.gov/highschool/.
- The EPA research sties focuses on information for college students and researchers: www.epa.gov/epahome/research.htm.

Environmental Defense – Horizon 2100
http://www.environmentaldefense.org/documents/2777_nchorizon2100.pdf

This document was created by Environmental Defense to help guide conservation efforts in North Carolina. Because it includes a lot of information about the effects of climate change in this state, it is a useful resource for educators who wish to bring the message of climate change to a more local level.

Project Budburst
www.windows.ucar.edu/citizen_science/budburst

This project uses citizen science to collect information on local timing of leafing and flowering native trees and flowers in different places around the country. Over time, this information will help scientists understand the ways that climate change is affecting life cycles of plants. It has a link to a page specifically on climate change that explains in simple language what we can expect to happen with GCC (based on the 2007 IPCC report). This is a great resource for clearly outlining the basics of climate change to middle-school-aged students.

VI. TEACHING ENRICHMENT OPPORTUNITIES

National Environmental Education and Training Foundation
www.neetf.org

NEETF is a non-profit, private organization chartered by Congress in 1990 that develops policies and programs for environmental educators and new grant-making approaches that could be helpful for science centers. The website also contains environmental education links to core societal goals (better health, improved education, environmentally sounds and profitable business) and explains how to present your message about GCC in the context of these goals. It also focuses specifically on adult education: "Report Cards," "Watershed Education," and "Drinking Water Reports." I the K-12 education sections it has ideas for a program called "No **Subject** Left Behind"

Teacher's Guide to Environmental Education Programs and Resources
www.ee.enr.state.nc.us

The Teacher's Guide outlines professional development opportunities for teachers around the state of North Carolina, as well as environmental education support materials, education materials that teachers can order or find online, and EE field trips and site visits.

One exciting program in the Guide is "Using the outdoors to teach experiential science" (UTOTES). "UTOTES is an exciting teacher education project designed to improve elementary education by transforming your school grounds into an active, diversified educational resource. Emphasis is placed on teacher, student, and community involvement to enhance the school grounds. Materials are provided to the school to create wildlife habitat through planting wildflowers, shrubs, and trees; providing cover for birds and small mammals, creating water sources for wildlife; and returning selected moved areas to maintained meadows or natural sites. Hands-on activities are demonstrated throughout the workshops to facilitate using the outdoors to teach all areas of the curriculum" provided through the NC Museum of Natural Sciences. The Guide also includes "Teacher Treks – One Day Explorations" and "Extended Explorations" provided by the museum. Environmental Education Certification Program information is also found here. Of the 102 programs and resources listed in the guide, however, none focus explicitly on teaching or learning about GCC.

North Carolina Center for the Advancement of Teaching
www.nccat.org

NCCAT funds teachers to visit their campus and shows them the latest ideas and activities they can use with their students. Although this program is only for public school teachers, it is a great supplemental program that enhances science teacher training.

Time for Kids
www.timeforkids.com/TFK/

The classroom version of "Time for Kids" magazine was cited by many students in the MPSC surveys (Appendix One) as being used in their classroom, and several said that this was a way they would like to learn more about global warming. It sets up issues in a current events format. It does contain advertising and is a commercial enterprise owned by Time Inc.

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